WILD SALMON CENTER

# A Proactive Sanctuary Strategy to Anchor and Restore High-Priority Wild Salmon Ecosystems[1]

SALMON 2100 PROJECT

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[1] The views and opinions presented in this chapter are those of the authors and do not necessarily represent those of any organization.

## I. INTRODUCTION

We have failed to sustain healthy populations of wild salmon in the North Atlantic and more recently in the southern and central regions of the North Pacific (Lichatowich 2001; Montgomery 2003; Augerot 2005). Our inability to coexist with salmon is startling because both Atlantic (*Salmo salar*) and Pacific salmon (*Oncorhynchus spp*.) have been valued very highly by human cultures throughout history and have been the focus of some of the most ambitious and expensive recovery efforts directed at any wild fish. Despite concerted, large-scale conservation initiatives in the United States and Canada, beginning in the 1930s, we have been unable to slow the decline of wild salmon populations in the southern portion of their range. Unless we direct our recovery and restoration funding toward priority salmon ecosystems, there is a strong possibility that continued human population growth, increasing resource scarcity and our globally-oriented economic system will drive many wild salmon populations in western North American toward extinction.

In this chapter we describe a salmon sanctuary strategy designed to protect and restore selected centers of salmon productivity and diversity within river basins located in each ecological region of western North America (Figure 1). It is important to note that this strategy is not a comprehensive solution to salmon declines. It will not restore *all* of the region's salmon populations to healthy levels. Nor should adoption of this strategy result in the weakening of County, State and Federal regulations and statutes, or local volunteer efforts to protect salmon and their habitat outside of sanctuary or stronghold basins.

The salmon sanctuary concept is a precautionary approach intended to focus our conservation efforts first and foremost on the irreplaceable river basins. It will proactively channel resources toward the long-term protection of the remaining salmon ecosystems with the highest functionality, salmon biodiversity, and inherent salmon productivity. These relatively healthy salmon populations are the most likely to survive the threats they will face over the next 100 years. The sub-basin ("stronghold") sanctuary strategy featured in this chapter is one element of a larger, North Pacific sanctuary strategy described briefly below. We present this concept as a policy that, if adopted, will have a high probability of supporting substantial, sustainable runs of wild salmon throughout western North America and the northern Pacific into the next century.

Implementing the salmon sanctuary strategy will require breaking rank from the entangled and self-perpetuating social, political, and economic systems that dictate current salmon management and recovery approaches (Wilkinson 1992; Bella 1994). We argue that the current practice, driven by the Endangered Species Act (ESA), of focusing resources on restoring the most endangered populations – those suffering from the greatest threats – is a losing strategy. Unless we also act aggressively to invest conservation resources to protect or "anchor" the most robust remaining populations in ecologically functional river basins, we will condemn our remaining wild salmon to a downward spiral of declining habitat conditions and possible extinction (Figure 2).

Section II of this chapter describes some of the fundamental problems that plague efforts to restore salmon: our tendencies to invest salmon recovery funds where they have the lowest

chance of success and to treat the symptoms rather than the causes of salmon decline. Section III describes our policy alternative, explains the sanctuary strategy, and defines goals and objectives for a sanctuary network. Section IV offers a framework for implementing the sanctuary strategy, and Section V briefly addresses potential reactions to the sanctuary strategy and issues of political will and funding necessary to ensure sustainable runs of wild salmon beyond 2100. Although the authors recognize that the geographic scope of the Salmon 2100 project extends to the southern third of British Columbia, Canada, our arguments are based largely on United States salmon recovery law and politics because we are most familiar with the situation in the United States.

## II. THE PROBLEM

Current investments in salmon recovery will not succeed because there are no clear salmon river habitat conservation priorities across river basins to focus and coordinate the efforts of the many disparate organizations with jurisdiction over freshwater habitat drivers. The primary responsible organizations (NOAA Fisheries, Canada Department of Fisheries and Oceans[1], Tribes, and States and Provinces) do not have the necessary authority to mitigate threats to salmon habitat. They cannot productively address the effects of the core drivers described by Lackey et al. (2006, this volume) in Chapter 3 – the predominant rules of commerce, increasing scarcity of natural resources, human population growth, and the apparent incongruity between individuals' stated preferences for salmon conservation and their day-to-day behaviors – on

[1] Canada's Habitat Policy (1986) grants the Department of Fisheries and Oceans Canada (DFO) the authority to permit activities that may harm salmon habitat, under the condition of no net loss. Any adverse effects of proposed development must be addressed by project design or through mitigation. A recent assessment of the effectiveness of habitat compensation strategies to address no net loss concluded that of the few projects (4 percent) where there was sufficient information to assess effectiveness, just over half of the projects could be interpreted to have achieved no net loss of productive fish habitat (Harper and Quigley 2005). While DFO has authority over Pacific salmon, the Provincial government regulates land use and land management practices.

freshwater salmon habitat. We must recognize that competition for salmon habitat (e.g., human demand for water, gravel, riparian lots for development, timber) will become more intense over the next century. The effect of these core drivers may become even more acute due to the potential adverse effects of global warming.

Prioritized river basins can provide the framework within which to organize and coordinate multi-agency cooperation. Alternatively, increased fisheries agency authority over habitat-altering development, perhaps using the Canadian Habitat Policy compensatory model, may channel the effects of the core drivers in such a way that humans and salmon could coexist for the next 100 years and high priority salmon populations may recover (Harper and Quigley 2005).

There are several dimensions to the mismatch between agency authority and the root causes of salmon decline in western North America.

***a. Current salmon recovery efforts have failed because they employ reactive strategies***

A fundamental weakness in salmon conservation efforts in the United States is that salmon recovery programs, driven by the ESA, are triggered only *after* salmon populations are recognized as being at risk of extinction.[2] Although the ESA has been the most significant driver for recent programs to protect wild salmon, NOAA Fisheries only has regulatory authority after anadromous fish have been formally listed as threatened or endangered. Given the great degree of local genetic adaptation in Pacific salmon and the relative isolation of particular populations, listing at the species level is not meaningful – Klamath River Chinook are not genetically or

ecologically equivalent to Fraser River Chinook salmon, for example. Therefore, in accordance with the ESA, NOAA Fisheries has devised units referred to as "Evolutionarily Significant Units" (ESUs). ESUs are defined as a group of populations inhabiting a specific geographic area that comprise a unique segment of the species; they are reproductively isolated from other clusters of populations of the same species and represent an important evolutionary legacy for the species (Figure 3).

By the time a "species," or an evolutionarily significant unit, of salmon is sufficiently imperiled to be listed, the factors causing its decline are usually entrenched (e.g., dams, urbanization, channelization), thus making recovery extremely challenging both in practice and politically (Figure 4). The unlisted salmon ESUs and unassessed populations, which are our best investments for the future of wild salmon ecosystems, are managed by State fisheries agencies and ignored by NOAA Fisheries and the U.S. Fish and Wildlife Service until they, too, are candidates for listing under the ESA.

By contrast, the new Canadian Wild Salmon Policy will foster the designation of salmon conservation units (CUs) for all salmon species prior to listing under the Canadian Species at Risk Act (SARA).[3] The policy requires that strategic plans be established to ensure conservation and sustainable use for each CU. The plans will specify spawner abundance or "escapement" targets, identify habitat protection and restoration needs, and establish timeframes and priorities for action. The Department of Fisheries and Oceans Canada (DFO) anticipates that there will be

[2] Canada's Species at Risk Act provides more discretion than the United States' ESA to list or not list declining salmon "conservation units." The recently adopted Wild Salmon Policy (2005) acknowledges that proactive salmon and habitat management are more effective than reactive listings. The Policy is new and as yet untested.

approximately 60 planning units (representing combinations of species-specific CUs in a geographic area or, in some cases, subcomponents of CUs). If the DFO and other parties to the planning process are adequately funded, Canadian salmon advocates may be able proactively to stay ahead of the extinction curve.

***b. Reactive strategies treat only symptoms, not root causes***

Because salmon lifecycles occur over an interconnected suite of habitats, from freshwater to the ocean and back again, salmon are exposed to diverse, geographically dispersed anthropogenic and natural disturbances. Within the distributional range of Pacific salmon in the U.S. Pacific Northwest, 58 percent of the lands are privately owned. Essential salmon habitat in western North America has suffered "death by a thousand cuts" due to individual, corporate and government resource use decisions (Lackey et al. 2006, Chapter 2, this volume). U.S. land use planning in the region is represented by a patchwork quilt of authorities – Federal natural resource agencies, State agencies, Tribal governments, and counties – that do not necessarily consider salmon habitat conservation as a primary objective. Under the U.S. Northwest Forest Plan, Federal agencies in Washington, Oregon and Northern California do, however, have mandates to consider salmon habitat as part of a comprehensive aquatic conservation strategy (USDA Forest Service and USDI Bureau of Land Management 1993). Local planning has typically not addressed salmon or other wildlife habitat conservation in a comprehensive fashion, and planning jurisdictions rarely coincide with river basin boundaries (Cohn and Lerner 2003).[4]

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[3] The text of SARA is available at www.sararegistry.gc.ca/the_act/default_e.cfm. The Wild Salmon Policy may be obtained at http://www-comm.pac.dfo-mpo.gc.ca/publications/wsp/default_e.htm .

[4] The situation in British Columbia differs dramatically, in part because 94 percent of the lands are publicly owned. The Province of British Columbia adopted a Province-wide Land and Resource Management Planning process in 1993, and plans are either approved or under development for more than 80 percent of the Province (http://srmwww.gov.bc.ca/rmd/lrmp/data/policy/whatis.htm ). The North Coast Land and Resource Management

There are, unfortunately, plenty of good examples of incremental habitat destruction and technical fixes. In the Columbia River Basin, Federal and State agencies have invested in hatcheries, fish ladders, smolt flumes, refrigerated barges, and now a series of removable spillway weirs (Figure 5), the latter at $20 million apiece (Kershaw 2005). Washington, Oregon, and California combined spend $61.78 million per year on hatchery systems as a technical alternative to natural salmon reproduction in the wild.[5] Hatchery propagation has failed to maintain viable wild Pacific salmon and steelhead runs and has instead masked the long-term core problems that have led to the extirpation of many wild populations (Myers et al. 2004).

***c. Salmon habitat restoration funding is not distributed where it will have the best chance of success***

The lack of political will together with poor agency coordination has spread resources thinly, undermining their efficacy. Indeed, funding equity is often a mandated policy objective, even when it is contrary to achieving measurable restoration results (Wu et al. 2003). Thus current recovery efforts are not only reactive, but often are implemented in the wrong places or with insufficient concentration of effort to achieve the desired results. Riparian fencing projects for livestock exclusion provide a good example. Unless these projects are deployed densely enough to alter some threshold level of stream kilometers, and both upstream and downstream

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Plan provides detailed management guidance to protect aquatic and riparian ecosystems (B.C. Ministry of Sustainable Resource Management 2005).

[5] The hatchery division of Washington's Department of Fish and Wildlife spent $56.26 million for the 1999-01 biennium ($28.13 million annually) for 91 hatcheries of which 69 are dedicated to anadromous salmonids (WDFW 2002). Oregon hatchery funding in 2003 was approximately $22.9 million for 33 hatcheries (ODFW 2004); 65 percent of the output (by volume) was anadromous (G. Nandor, ODFW Hatchery Division, personal communication). California funding for FY 2004 on 10 anadromous salmonid hatcheries (including two Federally-funded and operated facilities) was $10.75 million (C. Knutson, California Department of Fish and Game, personal communication).

threats are taken into account, fencing projects may have highly localized effects with no benefit to salmon populations or overall river basin functionality (Wu et al. 2003).

Current recovery plans do not emphasize ecological function and full basin connectivity, though they are moving in this direction (e.g., John Day Subbasin Revised Draft Plan (CBMRCDA 2005)). A productive salmon ecosystem involves a network of interconnected habitats that are altered periodically by natural disturbances. Connectivity from the headwaters downstream, laterally and vertically through the floodplains and out to sea is essential for providing migration corridors, refuges from predators, and spawning and rearing habitats (Williams et al. 1999). Restoration efforts that focus on just one scale or component of these systems will not succeed in sustaining healthy wild salmon populations (Hauer et al. 2003).

***d. To be successful, we need a new approach—the Sanctuary Strategy***

The authors argue that the policies and criteria for allocating Federal and State funds for salmon restoration and recovery must be reorganized to target protection and restoration of the healthiest salmon ecosystems and populations within each ecological region, defined at two biological and geographic scales (see Section III). In western North America, priority conservation sites must be distributed to capture the representative biodiversity of native salmonids (species, genetic and life history) throughout California, Oregon, Idaho, Washington, and southern British Columbia. Protecting the existing habitat and restoring the functional habitat connectivity in these systems, from the headwaters to the ocean, should be a primary management goal. If society can embrace this goal, then we have the chance—perhaps our last chance—to leave future generations a system of coldwater ecosystems that are diverse and

productive, that still provide pathways for wild salmon from the headwaters to the ocean and back, and that provide the opportunity for people to interact with wild salmon and the species they support in a natural environment (Figure 6).

The authors are arguing for coordinated prioritization within ESUs – to allocate scarce funds and political capital in such a way as to provide the highest probability for survival of the most robust representative elements of each ESU across western North America. There are many relatively intact river basins with high biological productivity, biophysical complexity, and diversity of wild salmon and associated species across the region (Figure 7). Although essential for the future of wild salmon, many of these areas have not been prioritized for restoration or protected in any way.[6] Regrettably, those basins and salmon stocks with the least biological value or potential for recovery have often been the focus of our attention.

## III. THE SANCTUARY STRATEGY

The salmon sanctuary concept – creating protected areas that extend from the headwaters to the sea – is over a century old (Rahr et al. 1998; Lichatowich et al. 2000). One of the nation's first fish conservationists, Livingston Stone, first proposed the idea in 1892 at the America Fisheries Society's twenty-first annual meeting. Unfortunately, the idea faded without much support as fish hatcheries became the dominant instrument for salmon management (Lichatowich 1999; Taylor 1999).

[6] Recovery plans for basins or sub-basins are beginning to indicate priority areas and/or populations for restoration and preservation action. Oregon and California salmon recovery funding entities require watershed analyses and prioritization. Examples include the Lower Columbia Salmon Recovery and Subbasin Plan (WLC-TRT 2003), the

The sanctuary or refuge concept was revived in the early 1990s in the context of debates about old-growth forest conservation and forestalling ESA listings for Pacific salmon. Pacific Rivers Council's "Entering the Watershed" (Doppelt et al. 1993) assessed the limitations of the uncoordinated local, State and Federal approach to protecting freshwater biodiversity and made many proposals for change. The central tenet of their work was to protect the most intact sub-drainages first, and restore connectivity and functionality in a downstream progression. The notion of sub-basin level refuges or "refugia" was eventually embedded in the Northwest Forest Plan as a central component of the Aquatic Conservation Strategy, referred to as "key watersheds" (USDA Forest Service and USDI Bureau of Land Management 1993). There has been no formal assessment of the effectiveness of the key watershed strategy for protecting Pacific salmon and trout on Federal lands (K. Burnett, USDA Forest Service Pacific Northwest Research Lab, personal communication).

Today there are small pockets of healthy wild salmon populations located throughout their range in western North America, and larger healthy populations across the full Pacific salmon distributional range around the North Pacific Ocean. In western North America, many of these populations persist at only a fraction of their historical abundance. However, these healthy populations are our best hope for preventing the extinction of locally-adapted salmon populations that have evolved with the landscapes of western North America and still offer a chance to sustain and rebuild salmon diversity and abundance to ecologically and economically meaningful levels. As a subcomponent of a range-wide North Pacific salmon conservation strategy, we propose to resurrect the idea of salmon sanctuaries as a strategy to support conservation across

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John Day Subbasin Revised Draft Plan (CBMRCDA 2005), and the Recovery Strategy for California Coho Salmon (CDFG 2004).

all land ownerships, and stand behind it as a policy option that can protect and sustain wild salmon for generations to come. Combined with the current body of County, State and Federal land, water and fisheries conservation law and policy, the sanctuary strategy will provide a strong chance of sustaining the region's wild salmon heritage.

### *a. Goals and Objectives*

We view the creation of a series of salmon sanctuaries across the current range of Pacific salmon (hereafter referred to as the North Pacific) as a core, precautionary strategy. Sanctuaries do not specifically call for new land and water regulations, but are places where public and private resources are focused on supporting local communities to implement efforts to protect and restore wild salmon and their habitats. The North Pacific network will anchor and help to rebuild salmon productivity and diversity to biologically and ecologically meaningful levels. The three principal objectives are to:

1. Target a **series of intact and diverse (in terms of life histories, genetics, and species) Pacific salmon populations in full basin sanctuaries** across the North Pacific whose inherent productivity and biodiversity provides the capacity to serve as source populations for other river systems. Restore abundance where necessary.

2. Ensure the maintenance of **functional habitat connectivity from the headwaters to the estuary** to provide the habitat necessary to support salmon productivity and diversity. Provide habitat restoration where necessary.

3. Establish a **system of strongholds (regional priority sub-basins)** within the context of Evolutionarily Significant Units or Conservation Units in western North America to focus societal initiatives and maintain core economic, cultural, and ecological salmon values as effectively as possible.

### *b. Ecological Assumptions*

We assume that Pacific salmon require functionally intact, complex river basins (Figure 8) to ensure continued expression of genetic and life history diversity (Hauer et al. 2003;

Northwest Power Planning Council 2000).[7] Genetic and life history diversity are the basis for species' resilience (Hilborn et al. 2003; McElhany et al. 2000; Peterson et al. 1998). There may be threshold abundances of adult salmon necessary to sustain population productivity, through fertilization of freshwater systems with marine-derived nutrients brought home by salmon (Knudsen et al. 2002). There may also be threshold abundances or habitat characteristics that trigger salmon straying, the mechanism underlying recolonization from sanctuary basins to other rivers.

There are many unknowns regarding the role of salmon abundance and within-basin distribution as factors that influence the long-term productivity of salmon rivers. Poorly managed human catch (commercial, sport, Tribal for-profit and subsistence) may lead to poor abundance from an ecological standpoint (Mundy 1997; Frissell et al 1997). As fish population levels decline due to unfavorable ocean rearing conditions or continued harvest pressures, understanding salmon reproductive behavior, habitat, ecology and evolution become more critical to predicting whether populations can recover (Hutchings and Reynolds 2004). Assuming that the role of ocean conditions, ocean harvest and natural predators can be accounted for, salmon sanctuary basins will serve as natural laboratories where biophysical interactions can be evaluated and used to improve recovery planning in heavily altered river basins. Ongoing research at long-term Salmonid River Observatory Network sites (SaRON, see http://umt.edu/flbs/Research/ SaRON.htm), e.g., Kol River (Kamchatka), Kitlope River (British Columbia), Kwethluk River (Kuskokwim Basin, Alaska), and Bristol Bay rivers (Alaska) will help to establish meaningful salmon abundance, productivity and diversity goals.

[7] Functionally intact systems need not be wilderness, but must allow for natural ecological river dynamics sufficient to maintain wild salmon. Salmon recovery planners in the Puget Sound refer to "properly functioning conditions," or habitat sufficient for all salmon populations to exist in healthy, self-sustaining levels with less than a 5 percent probability of extirpation over a 100-year period (CBMRCDA 2005).

### *c. A Two-tiered Approach*

Human population pressures and "edge of range" effects shape the pattern of salmon declines that are most evident at the southern edge of the salmon's range on both sides of the North Pacific (Augerot 2005). Where human populations are lowest, – across much of the Russian Far East, Alaska and the northern two-thirds of British Columbia--salmon river basins have preserved their ecological functionality and productivity. Western North America has been significantly altered by humans for more than a century, and its landscapes are highly fragmented, especially in the lowlands (Meengs and Lackey 2005).

The authors envision a two-tiered salmon sanctuary approach, locating full-basin **sanctuaries** primarily in unfragmented landscapes (Figure 9), and sub-basin scale **strongholds** in the fragmented landscapes of western North America (Table 1). The remainder of this chapter will focus primarily on the creation of a salmon stronghold network in western North America.

#### **North Pacific Scale: Salmon Sanctuaries**

Our primary criteria for salmon sanctuaries (Figure 10) at the North Pacific scale are (1) inherent biophysical productivity; (2) species, life history and genetic diversity; and (3) current ecological functionality (undeveloped floodplains, no mainstem dams, no artificial propagation). Sanctuaries encompass full river basins, from the headwaters to the estuary. In some cases, a sanctuary may encompass a suite of adjacent rivers. Most sanctuary basins will not be governmentally-designated protected areas, but will instead be sustainable multiple use areas with special priority for salmon conservation (i.e., natural salmon reproduction). There may be

several protected areas within the basin, safeguarding critical spawning and rearing habitat.

It is unlikely that there will be more than four to six sanctuary river basins in the heavily populated region that is the focus of this chapter: southern British Columbia to California. Many of these places are intensively altered by humans, and it will be far more challenging to create meaningful full basin sanctuaries in western North America than in the sparsely settled northern portions of the Pacific salmon distributional range.

## Western North American Context: Salmon Strongholds

In the fragmented landscapes of western North America, resources should be targeted to protect priority sub-basins or smaller coastal river basins for wild salmon within ESUs and Canadian Conservation Units (CUs). Many western North American salmon ecosystems lack functional connectivity between the estuary and relatively more intact tributary basins, and salmon populations are not as productive or diverse as in northerly, relatively pristine systems from central British Columbia north to Alaska and west to Russia. However, tributary-scale basins present important opportunities to prevent extinction of locally adapted genetic and life history diversity (the irreplaceability principle) and provide a chance to focus restoration efforts on systems that have the potential for long-term health and recovery. We describe these places where these opportunities are greatest as **salmon strongholds** (Figures 11 and 12).

To select salmon strongholds, we must clearly determine the relevant conservation units and the populations within them. This step is essential to selecting an optimal cross-section of river basins, to provide ecological insurance for the persistence of salmon. Genetic and life

history biodiversity provide the raw material for future evolutionary processes, including river recolonization. In western North America, the NOAA Fisheries ESU classification and forthcoming Canadian CUs provide the most appropriate framework. Exactly how many salmon populations and associated river basins would be necessary to ensure salmon persistence and resilience is not certain, but selecting two to three per conservation unit would provide modest redundancy against random natural events and thus represent a good starting point (Moyle and Yoshiyama 1994).

In western North America, some **salmon strongholds** may progress to become salmon sanctuaries as native salmon populations attain functional viability (healthy, self-sustaining condition with less than 5 percent probability of extirpation over 100 years) and as functional connectivity is extended downstream to the ocean through habitat restoration. Ensuring floodplain functionality and natural river flow regimes will be very challenging in many of these places due to competing uses for the water and the sites (e.g., airports, towns, farms, tree plantations). Without functional connectivity from tributaries to the estuary, however, strongholds may have a tenuous future as havens for salmon.

It is important to note that we are not advocating that major river systems or ecological regions, where salmon are the most threatened, be excluded from the stronghold system if they represent unique ESUs. Examples include the Upper Columbia, Sacramento, and San Joaquin Rivers. The authors are proposing that the *relative* strongholds, or "last, best" river basins or sub-basins for these ESUs be identified, using the criteria described below. These basins would then be elevated to receive the highest protection/restoration priority within their respective ESU or

analogous conservation unit. A substantial portion of the technical and financial support for salmon restoration and recovery should be targeted toward basins where there is the greatest probability of long-term habitat and population viability. Some river basins or sub-basins will receive less support than they do now, because there is a finite amount of money and support available for salmon programs (Figure 13).

The authors do not propose to eliminate salmon conservation efforts outside of priority basins. State and Federal endangered species laws will continue to be applied in every river basin, as will Provincial, County, and State land-use planning and zoning. There will always be some level of locally restricted private and government funding.

Current U.S. salmon recovery policy is to recover target "species," or ESA-listed ESUs, to the point where there is adequate assurance of persistence into the future, based on assessments of population viability within the ESU (NOAA Fisheries 2000). While viability, defined as "at negligible risk of extinction due to demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame" (McElhany et al. 2000), may be sufficient for delisting under the ESA, it is insufficient for the sustainability of ecosystem values and human use. In order to have significant wild salmon populations in 2100, as a society we must select a subset of populations representing each ESU to receive more focused attention for habitat protection and recovery on public and private lands. These actions must be accompanied by changes in harvest and hatchery policy, to ensure resilience against climate change and land use change accompanying human population growth over the next century.

**Table 1. Definitions**

**Salmon sanctuary:**

A *headwaters-to-the-ocean river basin or cluster of basins* where salmon populations are abundant and diverse (genetically and in terms of life history) and where habitat is largely intact and ecologically connected (undeveloped floodplains, no mainstem dams, little to no artificial propagation). Sustaining wild salmon abundance, diversity and population structure should be central to the land, water and fish management in the basin. The Kitlope River (1,219 sq. miles; British Columbia) can be considered a salmon sanctuary, and is an example of a whole basin protected area. The Kol River (843 sq. miles; Russia) also qualifies.

**Salmon Stronghold:**

A *sub-basin* providing hospitable habitat conditions for wild salmon populations representing the productivity and diversity for the Evolutionarily Significant Unit (U.S.) or Conservation Unit (Canada). A stronghold may contain existing protected or restricted use areas (e.g., National Forests, Fish and Wildlife Refuges, parks), ensuring some degree of ecosystem connectivity and functionality. The North Umpqua River (1,350 sq. miles; Umpqua River Basin, Oregon) may be considered a stronghold for summer steelhead. Strongholds may, as in this example, be large areas. They are distinguished from **sanctuaries** by less than fully functional connectivity of habitats from headwaters to the ocean**.**

**Salmon sanctuary and stronghold selection criteria**

The predominant principle now used to prioritize spending on salmon recovery and

habitat restoration is vulnerability, which leads to action only after success has become costly and uncertain. For proactive conservation action, the authors recommend that irreplaceability be the primary principle for sanctuary and stronghold selection.

Certain rivers basins are irreplaceable because they contain exceptionally high levels of wild salmonid productivity and diversity (McElhany et al. 2000). These systems may serve to anchors conservation units, acting as repositories of genetic diversity and potential source populations during poor environmental conditions (Cooper and Mangel 1999; McElhany et al. 2000). Additionally, some rivers contain salmon conservation units (e.g., an ESU) whose range is limited and for whom few habitat options exist (e.g., Sacramento River winter Chinook). These latter salmon populations, while perhaps not currently vulnerable, are predisposed to becoming so and should also be the focus of proactive conservation efforts (Eken et al. 2004).

To generate a first, coarse approximation of sanctuary and stronghold sites, we recommend using quantifiable criteria and thresholds to create a map of sanctuaries and strongholds from California to central British Columbia. Our first-cut criteria will target rivers with high relative abundance and species diversity.

## IV. IMPLEMENTING THE SANCTUARY STRATEGY

Implementing the sanctuary strategy will require bold political choices. Strategic prioritization of salmon conservation and recovery funds will have to be supported politically at both the State and Federal level and in the communities where the sanctuaries and strongholds are located. The leadership must initially come from the Governors of California, Oregon,

Idaho, and Washington, and the Premier of British Columbia, and be supported by executive authority at the Federal level in Canada and the United States as well as in Parliament and Congress.

Together with Federal authorities from Canada and the United States, the States, Provinces, and Tribes must undertake a coordinated four-step process:

1. Conduct a region-wide prioritization of the candidate sanctuaries and strongholds for each salmon species and ESU;

2. Assert sanctuary and stronghold priority for allocation of technical and financial resources to promote restoration, conservation land ownership (including working farms and ranches), and redirection of funds from hatcheries;

3. In partnership with local communities in candidate sanctuary and stronghold basins, develop incentive and communications programs to build local ownership and support for sanctuary/stronghold programs; and

4. Complete, fund and implement whole basin conservation plans (habitat and fish management) for priority basins, analogous to Northwest Power and Conservation Council sub-basin plans for the Columbia River (e.g., CBMRCDA 2005).

Our proposal will not increase the regulatory burden inside sanctuary and stronghold basins beyond that of other rivers in the region. Instead, it will target funds for restoration and habitat protection (e.g., land or easement acquisition, stewardship agreements, or conservation leases) where they will have the highest probability of long-term success.

***a. The Best Vehicle for Prioritization***

To implement the sanctuary strategy, a region-wide U.S. and Canadian prioritization process must be completed to identify candidate sanctuaries and strongholds. The best legislative vehicle for prioritization in the United States is the Endangered Species Act and its

implementing regulations contained in the U.S. Code of Federal Regulations (CFR). Prioritization could occur either via the ESA recovery planning process or through the development of candidate conservation agreements (CCA). CCAs are formal agreements between NOAA Fisheries (or the U.S. Fish and Wildlife Service) and one or more private parties, committing these parties to a set of voluntary measures to reduce or eliminate threats to candidate species for ESA listing. Since 1999, CCAs have been granted to private and other non-Federal property owners with legal assurance that if listing does occur, future regulations will not be more stringent than the original CCA (USFWS 2002).

Many potential strongholds in the United States hold salmon populations currently listed under the ESA and thus already fall within the NOAA Fisheries consultation requirements under ESA Sections 7 and 9 16 U.S.C. §§ 1536, 1538 (1988). The success of a prioritized stronghold framework depends largely on its ability to operate within the existing regulatory structure of the ESA, and specifically the enforcement provisions found in Sections 4, 7, 9 and 10. 16 U.S.C §§ 1533, 1536, 1539 (1988). These requirements do not allow prioritization between ESUs themselves. Rather, each ESU is treated as a distinct species that must be recovered once it has been listed.

Prioritization at the sub-ESU level, however, is allowed, and such sub-ESU prioritization will enable the designation of river basin salmon strongholds. Within this sub-ESU framework, more stringent standards for "no jeopardy" may be applied to specific populations. Similarly, this framework will enable a tailored approach to the ESA's "no adverse modification" clause as it applies to critical habitat in specific river basins. Finally, this framework will enable the

directed application of Federal recovery funds available under ESA sections 4 and 6. 16 U.S.C. §§ 1533, 1535 (1988). For example, Malibu Creek could be prioritized as a stronghold for steelhead within the Southern California ESU, thereby allowing it to receive greater federal recovery funding than the nearby Ventura River located in the same ESU.

In order to coordinate and fund recovery most effectively, multi-species recovery plans (Section 4) should be developed that identify and prioritize strongholds. 16 U.S.C. §1533 (1988). Indeed, NOAA Fisheries Technical Recovery Teams appear to be moving in this direction with a multi-species plan for the Lower Columbia River that places a differential emphasis on healthier core populations (WLC-TRT 2003).

Although success depends in part on the ability to garner Federal funding, a stronghold strategy will not be solely dependent on Federal appropriations. State, municipal, and private funds can be used to augment Federal monies. For example, the discretionary government restoration funding, such as that available from the Oregon Watershed Enhancement Board (OWEB) or the Washington Salmon Recovery Funding Board (SRF Board) could augment Federal Land and Water Conservation Fund appropriations.

Prioritized basins could be eligible for additional funding, tax credits and other benefits analogous to those provided to urban "special enterprise zones." Broad public/private coalitions should build support for implementing conservation strategies and should marshal resources to provide market-based incentives for land and water conservation. Basin-wide Watershed Councils could play a leading role to coordinate efforts within basins, including a robust

monitoring and evaluation program to ensure effectiveness in meeting conservation goals and targets.

Differential standards for adverse modification from one river basin to the next within an ESU may cause legal dilemmas of equity before the law. Focused and holistic landscape management is a wise investment from an ecological standpoint, but legally, socially and economically there is a need to create fairness for landowners. Both the Federal government, through the Departments of Interior and Commerce, or the States themselves may choose to reallocate cost savings from low priority areas to purchase easements or implement restoration activities in high priority, stronghold basins, but the regulatory burden must not penalize any particular class of landowner.

Ultimately Federal, State, and local governments must be legally accountable for achieving recovery in a broad sense, above the administrative floor of biological viability currently established by the ESA. Tribal treaty rights to salmon also invoke a legal obligation to achieve more than biological viability and will have to play a role in prioritization as well (NOAA Fisheries 2000).

Given that Federal regulations under the ESA provide Federal agency discretion to prioritize specific salmon populations and the associated river basins, it will take political will from the Secretaries of Interior and Commerce and the Governors of the western states to implement such an approach.

In Canada, however, the situation may be slightly different. With the new Wild Salmon Policy (2005), the Department of Fisheries and Oceans Canada (DFO) no net loss Habitat Policy (1986), and the comprehensive regional planning process mandated by the provincial Ministry for Sustainable Resource Management, it may be more straightforward for Canada to embrace the sanctuary strategy than it will be for the United States under the ESA.

***b. Legislative Changes***

The ESA would not need to be amended to facilitate a prioritization of salmon stronghold basins, but it will require public consensus to differentially apply standards and funding allocations between stronghold and non-stronghold sub-basins, particularly to protect government agencies from litigation under the jeopardy clause.

Effective conservation of salmon sanctuaries and strongholds will require impressive levels of coordination across many jurisdictions and actors. The Federal Lands Riverine Management Act (Doppelt et al. 1993) provides one potential solution by clarifying Federal agency authority over aquatic ecosystems on Federal land, by providing clear management goals, and by coordinating practices across agency jurisdictions. The Act also provides the framework for a nationwide system of strongholds. This Act would need to address non-Federal lands and actors as well, however.

As noted earlier, Canada's Habitat Policy (1986) takes a different approach by beginning to consolidate disparate authority over habitat. The Policy grants the DFO the authority to permit activities that may harm salmon habitat with the goal of preventing a net loss of habitat.

This provides an intriguing model, but one whose effectiveness has been difficult to establish to date due to inadequate effectiveness monitoring (Harper and Quigley 2005).

It may also be particularly useful to pass authorizing legislation mandating the creation of protected areas in critical portions of salmon stronghold and sanctuary river basins, as we have for migratory birds under the North American Migratory Waterfowl Management Plan (Phelan 2003).

***c. Land Management in Sanctuary and Stronghold Basins***

The majority of sanctuary and stronghold basins will not likely be fully encompassed by protected areas (parks, refuges, and other special land use classifications). We expect that full basin protected areas, such as those on the Kol River (Kamchatka, Russia) and the Kitlope (British Columbia, Canada) will be the exception. In many sanctuary and stronghold basins, local and regional stakeholders (perhaps organized as Watershed Councils) may choose proactive habitat acquisition and easements as a core stronghold strategy in tandem with existing restoration programs. In this case, endowed locally or regionally managed land trusts would provide for local ownership and conservation funding capacity in perpetuity.

***d. Funding***

Funding a salmon sanctuary system will require a long-term, focused reallocation of public and private monies. The funding needed for habitat protection and restoration could cost $100 to $500 million for each stronghold basin (Zwane and Sunding 2005), not including habitat inventory and monitoring, land and water acquisition, easements, and landowner incentive

programs. In the United States, prioritization of three stronghold subbasins per species-based ESU could total 39 sites. If U.S. taxpayers and private entities were to invest $100 to $500 million per site over at least two Chinook life cycles (eight to 12 years), a total of $3.9 billion to $19.5 billion would be needed.[8]

The North America Waterfowl Management Plan (NAWMP) successfully protected over 5 million acres of wetland ecosystems, a majority of which came from private funds (Phelan 2003). This is the acreage equivalent of 27 Hoh River (Washington) basins or 72 Malibu Creeks (California). With the support of stakeholders, interest groups, and multiple levels of government, sufficient funding for a salmon sanctuary system is not an unreasonable goal.

Consider the Columbia River Basin, which now has 13 ESA listings for steelhead and salmon. Between 1982 and 2002, $3.3 billion were spent by the U.S. Government on salmon and steelhead restoration and conservation (USGAO 2002). In addition, the 11 Federal agencies involved in this effort spent an estimated $302 million in the last five fiscal years before 2002 on "modifications to mission-related projects that benefited, but were not specifically directed at salmon and steelhead" (USGAO 2002). The majority of these funds were spent on fish passage projects and hatchery operations. From fiscal year 1997 through fiscal year 2001, the U.S. Army Corps of Engineers alone spent $430 million on salmon passage-related programs at the lower Columbia and Snake River dams (USGAO 2002). This represents 73 percent of the Army

[8] The cost of habitat protection through acquisitions and easements alone could be substantial, but over the long-term will be less that that the periodic investments needed in habitat restoration or fish hatcheries. On Washington's Olympic Peninsula, the Wild Salmon Center and the Western Rivers Conservancy helped acquire 4,500 acres of forest land along the Hoh River (one of the most diverse and productive major salmon and steelhead rivers remaining south of Canada) from the Rayonier Timber Company for roughly $9 million. These acquisitions provided long-term protection for 50 percent of the private land along the Hoh River corridor and ensured that 80 percent of the Hoh River floodplain and riparian lands are in conservation status.

Corp's $590 million budget for salmon and steelhead recovery. These investments have had little measurable impact on salmon recovery in the Columbia River Basin.

Very little of this funding goes toward habitat protection and restoration. For example, the Bonneville Power Administration spent only $20-40 million annually on habitat restoration from 2001-2003, out of an annual fish and wildlife budget of $250 million and a total budget of $3 billion (Sheets 2004). This level of spending on habitat projects was $147 million less than that recommended by the Northwest Power and Conservation Council for 2001-2003 (Sheets 2004). The Bureau of Reclamation, the Federal agency that has the highest proportion of its recovery budget devoted to habitat acquisition and restoration, only devoted 22 percent ($31 million) of its salmon and steelhead recovery budget in FY 1997-2001 to these types of programs.

In addition to the funds being spent on hatcheries and on the recovery of salmon in the Columbia River Basin, the Congressionally-established Pacific Coastal Salmon Recovery Fund has an annual budget of $96 million (PCSRF 2004). The recently drafted Recovery Strategy for California Coho Salmon will require approximately $5 billion to be re-prioritized from existing budgets (CDFG 2004). The Pacific Salmon Commission, established by treaty between Canada and the United States for the conservation and management of Pacific salmon, includes a trust fund worth over $157 million for restoration and enhancement (PSC 2004). This is not an exhaustive list, but it gives an idea of the potential availability of funds for salmon strongholds. Clearly, some portion of these monies would still need to be spent on Columbia River basin

strongholds, but there are large sums that could be reallocated from hatchery support and technical fixes at mainstem dams to habitat acquisition and restoration.

Conservatively, total state, provincial and federal (U.S. and Canadian) spending on salmon conservation each year exceeds $1.5 billion, or $15 billion over a ten year period. If this could be reallocated to the sanctuary strategy, then an additional $4.5 billion would have to be raised over time.

## V. DISCUSSION

The sanctuary/stronghold strategy described here is not a "silver bullet" that will solve all of the region's salmon conservation challenges, but it is a pragmatic strategy that has a high probability of safeguarding our most important salmon ecosystems. Like most bold strategies, the sanctuary strategy may be controversial at both regional and local levels.

Pro-salmon conservation organizations could believe that this strategy implicitly abandons salmon restoration on non-sanctuary/stronghold rivers. Anti-conservation groups may perceive a conspiracy to increase government regulation of private property rights. Neither is true: we are only proposing a prioritization of salmon conservation resources. We are not suggesting new regulations, nor are we proposing that the salmon recovery efforts on non-sanctuary river systems be abandoned.

The main challenge in implementing the sanctuary strategy will be local willingness to participate. While the government must make more resources available for sanctuary and

stronghold basins, uninvited government designations of “sanctuary” or “stronghold” status risk driving local communities away from the sanctuary concept. How the program is planned and launched at the local level will be crucial for its long-term success. There will have to be careful efforts to build trust and integrate the needs of local communities. Creative incentives and community outreach efforts will be needed to convert wild salmon populations from regulatory burdens to valued community assets. Ultimately, success will be determined by the willingness of people region-wide to embrace a 100-year vision of healthy salmon rivers and culturally and economically vibrant communities (Figure 14).

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**References**


Augerot, Xan. 2005. Atlas of Pacific salmon: the first map-based status assessment of salmon in the North Pacific. University of California Press, Berkeley.

Bella. 1994. [Please Complete]

CBMRCDA (Columbia-Blue Mountain Resource Conservation and Development Area). 2005. John Day Subbasin Revised Draft Plan. Northwest Power and Conservation Council. Available: http://www.nwcouncil.org/fw/subbasinplanning/johnday/plan/. (July 2005).

CDFG (California Department of Fish and Game). 2004. Recovery strategy for California coho salmon: report to the California Fish and Game Commission. The California Department of Fish and Game. Available: http://www.dfg.ca.gov/nafwb/pubs/2004/CohoRecovery/CohoRecoveryStrategy.pdf. (July 2005).

Cohn, Jeffrey P., and Jeffrey A. Lerner. 2003. Integrating land use planning and biodiversity. Defenders of Wildlife, Washington, D.C.

Cooper, Andrew B., and Marc Mangel. 1999. The dangers of ignoring metapopulation structure for the conservation of salmonids. Fishery Bulletin 97:213-226.

Doppelt, Bob, Mary Scurlock, Chris Frissell, and James Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Washington, D.C.

Eken, Güven, Leon Bennun, Thomas M. Brooks, Will Darwall, Lincoln D. C. Fishpool, Matt Foster, David Knox, Penny Langhammer, Paul Matiku, Elizabeth Radford, Paul Salaman, Wes Sechrest, Michael L. Smith, Sacha Spector, and Andrew Tordoff. 2004. Key biodiversity areas as site conservation targets. Bioscience 54:1110-1118.

Frissell, Chris A., William J. Liss, Robert E. Greswell, Richard K. Nawa, and Joseph L. Ebersole. 1997. Resource in crisis: new measures for salmon management. Pages 411-444 *in* Deanna J. Stouder, Peter A. Bisson, and Robert J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman & Hall, New York.

Harper, David J., and Jason T. Quigley. 2005. A comparison of the areal extent of fish habitat gains and losses associated with selected compensation projects in Canada. Fisheries 30(2):18-25.

Hauer, F. Richard, Clifford N. Dahm, Gary A. Lamberti, and Jack A. Stanford. 2003. Landscapes and ecological variability of rivers in North America: factors affecting restoration strategies. Pages 81-105 *in* Robert C. Wissmar and Peter A. Bisson, editors. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and managed systems. American Fisheries Society, Bethesda, Maryland.

Hilborn, Ray, Thomas P. Quinn, Daniel E. Schindler, and Donald E. Rogers. 2003. Biocomplexity and fisheries sustainability. Proceedings of the National Academy of Sciences 100:6564-6568.

Hutchings, Jeffery A., and John D. Reynolds. 2004. Marine fish population collapses: consequences for recovery and extinction risk. BioScience 54:297-309.

Kershaw, Sarah. 2005. New slide may help salmon cross dams, but are they being taken for a ride? New York Times (April 19):A14.

Knudsen, E. Eric, Eric W. Symmes, and F. Joseph Margraf. 2003. Searching for a life history approach to salmon escapement management. Pages 261-276 *in* J. G. Stockner, editor. Nutrients in salmonid ecosystems: sustaining production and biodiversity. American Fisheries Society, Symposium 34, Bethesda, Maryland.

Lichatowich, James A. 1999. Salmon without rivers: a history of the Pacific salmon crisis. Island Press, Washington, D.C.

Lichatowich, James A. 2001. Pacific salmon life histories. Pages 59-63 *in* Oregon Trout (Organization), compiler. Oregon salmon: essays on the state of the fish at the turn of the millennium. Oregon Trout, Portland.

Lichatowich, James A., Guido R. Rahr III, Shauna M. Whidden, and Cleveland R. Steward. 2000. Sanctuaries for Pacific salmon. Pages 675-686 *in* E. Eric Knudsen, Cleveland R. Steward, Donald D. MacDonald, Jack E. Williams, and Dudley W. Reiser, editors. Sustainable fisheries management: Pacific salmon. Lewis Publishers, Boca Raton, Florida.

McElhany, Paul, Mary H. Ruckelshaus, Mike J. Ford, Tom C. Wainwright, and Eric P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of Evolutionarily Significant Units. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-42, Seattle.

Meengs, Chad C., and Robert T. Lackey. 2005. Estimating the size of historical Oregon salmon runs. Reviews in Fisheries Science 13:51-66.

Montgomery, David R. 2003. King of fish: the thousand-year run of salmon. Westview Press, Boulder, Colorado.

Moyle, Peter B., and Ronald M. Yoshiyama. 1994. Protection of aquatic biodiversity in California: a five-tiered approach. Fisheries 19(2):6-18.

Mundy, Phillip R. 1997. The role of harvest management in the future of Pacific salmon populations: shaping human behavior to enable the persistence of salmon. Pages 315-329 *in*

Deanna J. Stouder, Peter A. Bisson, and Robert J. Naiman, editors. Pacific salmon and their ecosystems: status and future options. Chapman & Hall, New York.

Myers, Ransom A., Simon A. Levin, Russell Lande, Frances C. James, William W. Murdoch, and Robert T. Paine. 2004. Hatcheries and endangered salmon. Science 303:1980.

NOAA (National Oceanic and Atmospheric Administration) Fisheries. 2000. Recovery planning guidance for technical recovery teams: 1 September 2000 draft. NOAA Fisheries Service, Northwest Fisheries Science Center. Available: http://www.nwfsc.noaa.gov/trt/guidanc9.pdf. (July 2005).

Northwest Power Planning Council. 2000. Return to the river. Northwest Power and Conservation Council. Available: http://www.nwppc.org/library/return/2000-12.htm. (July 2005).

PCSRF (Pacific Coastal Salmon Recovery Fund). 2004. 2004 Report to Congress, FY 2000-2003. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle.

PSC (Pacific Salmon Commission). 2004. 2002/2003 Eighteenth annual report. Pacific Salmon Commission. Available: http://www.psc.org/pubs/18thAnnualReport.pdf. (July 2005).

Peterson, Garry, Craig R. Allen, and C. S. Holling. 1998. Ecological resilience, biodiversity, and scale. Ecosystems 1:6-18.

Phelan, Sean. 2003. A Pacific Rim approach to salmon management: redefining the role of Pacific salmon international consensus. Environmental Law 33(1):247-290.

Rahr, Guido R., III, James A. Lichatowich, Raymond Hubley, and Shauna M. Whidden. 1998. Sanctuaries for native salmon: a conservation strategy for the 21st century. Fisheries 23(4):6-7.

Sheets, Edward. 2004. Restoring salmon: how are we doing? Open Spaces 7(1):14-21.

Taylor, Joseph E., III. 1999. Making salmon: an environmental history of the Northwest fisheries crisis. University of Washington Press, Seattle.

USDA (U.S. Department of Agriculture) Forest Service and USDI (U.S. Department of the Interior) Bureau of Land Management. 1993. Standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Attachment A to the Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. General Printing Office, Washington, D.C.

USFWS (U.S. Fish & Wildlife Service). 2002. Candidate conservation agreements with assurances for non-federal property owners. USFWS. Available: http://www.fws.gov/endangered/listing/cca.pdf. (July 2005).

USGAO (U.S. General Accounting Office). 2002. Columbia River Basin salmon and steelhead: federal agencies' recovery responsibilities, expenditures and actions. USGAO, Report GAO-02-612, Washington, D.C.

Wilkinson, Charles F. 1992. Crossing the next meridian: land, water, and the future of the West. Island Press, Washington, D.C.

Williams, R. N., W. E. McConnaha, P. R. Mundy, J. A. Stanford, R. R. Whitney, P. A. Bisson, D. L. Bottom, L. D. Calvin, C. C. Coutant, M. W. Erho, Jr., C. A. Frissell, J. A. Lichatowich, and W. J. Liss. 1999. Return to the river: scientific issues in the restoration of salmonid fishes in the Columbia River. Fisheries 24(3):10-25.

WLC-TRT (Willamette/Lower Columbia Technical Recovery Team). 2003. Interim report on viability criteria for Willamette and Lower Columbia Basin Pacific salmonids. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center. Available: http://www.nwfsc.noaa.gov/trt/wlc_viabrpt/body.pdf. (July 2005).

Wu, Junjie, Katharine Skelton-Groth, William G. Boggess, and Richard M. Adams. 2003. Pacific salmon restoration: trade-offs between economic efficiency and political acceptance. Contemporary Economic Policy 21:78-89.

Zwane, Alix P., and David L. Sunding. 2005. Coho salmon recovery in California: a summary of recent economic evidence. University of California, Davis, Department of Agricultural and Resource Economics. Available: http://www.agecon.ucdavis.edu/uploads/update_articles/v8n4_3.pdf. (July 2005).

## Figure Captions

Figure 1: The goal of the salmon sanctuary strategy is to select a system of river basins throughout the current range of Pacific salmon for targeted protection and restoration. This is a precautionary measure to ensure the persistence and resilience of Pacific salmon biodiversity to 2100 and beyond. The North Pacific network will anchor and help to rebuild salmon productivity and diversity to biologically and ecologically meaningful levels. (Source: Jeff Mishler, Wild Salmon Center.)

Figure 2: We argue that the current ESA-driven practice of focusing resources on restoring the most threatened populations that suffer from the most intractable obstacles is a losing strategy. Unless we act aggressively to invest conservation resources to protect or "anchor" the most robust remaining populations in ecologically functional river basins, we will doom our remaining wild salmon to a downward spiral of habitat condition, driving them from decline to possible extinction. (Source: John McMillan, Wild Salmon Center

Figure 3: To select salmon conservation priorities at either the North Pacific or western North American scale, we must clearly delineate the "evolutionarily significant units" (ESUs) and the population units within them. To ensure resilience for the species as a whole, we would judiciously prioritize river basins within the geographical footprint of an ESU or regional population in order to ensure that two to three populations per species of salmon and their freshwater habitat are protected. (Source: NOAA Fisheries.)

Figure 4: The cost of restoring salmon river basins increases with the amount of habitat degradation and magnitude of other limiting factors (dams, water withdrawals, etc.). In other words, the best long-term investments are those watersheds with the largest proportions of quality habitats and healthy salmon populations. Habitat protection is a better long-term investment than habitat restoration. (Source: Wild Salmon Center.)

Figure 5: In the Columbia Basin, Federal and state agencies have invested in fish ladders, smolt flumes, refrigerated barges, and now removable smolt passage weirs, estimated to cost $6 billion over the next ten years. For a fraction of this investment, comprehensive river restoration and conservation programs can be undertaken and protected in perpetuity on the Oregon and Washington coasts, where several rivers contain relatively healthy salmon populations. These programs may include land and easement purchases from willing sellers as well as other activities. (Source: Guido Rahr, Wild Salmon Center.)

Figure 6: If society can embrace the sanctuary strategy, then we have the chance—our last chance—to leave future generations a system of coldwater ecosystems that are diverse and productive, that still provide pathways for wild salmon from the headwaters to the ocean and

back, and that provide the opportunity for people to interact with wild salmon and the species they support in a natural environment. (Source: John McMillan, Wild Salmon Center.)

Figure 7: Across western North America, there are relatively intact river basins with high biological productivity, biophysical complexity, and diversity of wild salmon and associated species. An example is the western Olympic Peninsula, where five major salmon rivers flow from federally protected headwaters through private timber land to the continental shelf. These rivers still contain relatively healthy native populations of chinook, steelhead, and coho, as well as small populations of chum, sockeye, and cutthroat trout. Bull trout are the only ESA-listed species on the west side of the Peninsula. The region represents a historic long-term conservation opportunity. (Source: Ecotrust.)

Figure 8: A productive salmon ecosystem involves a network of interconnected habitats that are altered periodically by natural disturbance regimes. Connectivity from the headwaters downstream, laterally and vertically through the floodplains and out to sea are essential for providing migration corridors, refuges from predators, spawning and rearing habitats. Restoration efforts that focus on one scale or component of these systems will not succeed in sustaining healthy wild salmon populations. (Source: Guido Rahr, Wild Salmon Center.)

Figure 9: The Kurutagarova floodplain in Kamchatka is one example of the channel complexity and three-dimensional connectivity still present in intact rivers of the North Pacific. Unconstrained by channelization or riparian development, the river braids into secondary and tertiary channels and enriches the riparian forest during floods. Complexity and connectivity are assumed to be necessary components of healthy river systems that support robust salmon populations exhibiting high life history and genetic diversity. (Source: Guido Rahr, Wild Salmon Center.)

Figure 10: We expect that the North Pacific network would include four to six sanctuary river basins in the heavily populated region that is the focus of this chapter: southern British Columbia to California. We recognize that these places are intensively altered by humans, and it will be far more challenging to create meaningful sanctuaries in western North America than in the sparsely settled northern portions of the Pacific salmon distribution. The sites above are for demonstration purposes only. (Source: Wild Salmon Center.)

Figure 11: We propose two levels of salmon conservation priority sites: salmon sanctuaries (red circles) and salmon strongholds (yellow dots). Sanctuaries represent the most productive, diverse and intact salmon basins across the Northern Pacific Rim. In contrast, strongholds represent the sites within each ESU or Canadian Salmon Conservation Unit with the highest relative biological value. We anticipate there will be 30-40 strongholds and four to six sanctuaries from central British Columbia to California. The sites above are for demonstration purposes only. (Source: Wild Salmon Center.)

Figure 12: Salmon strongholds are river basins or sub-basins that contain the “last, best” salmon populations within each ESU or Canadian Salmon Conservation Unit. These strongholds are crucial to anchor the salmon biodiversity native to the Pacific Northwest, and to provide core populations to help rebuild local races of salmon and steelhead that have declined over much of their range. The Kilchis River in western Oregon, while affected by humans, remains home to the most robust chum salmon populations remaining south of Washington State. (Source: Guido Rahr, Wild Salmon Center.)

Figure 13: For the sanctuary strategy to succeed, a substantial portion of the technical and financial support for salmon restoration and recovery must be targeted toward basins where there is the greatest probability of long-term success. This will mean that some watersheds will receive less support than they do now, because there is a finite amount of money and support available for salmon programs. (Source: Guido Rahr, Wild Salmon Center.)

Figure 14: The main challenge in implementing the sanctuary strategy will be the willingness of local communities to participate. While the government must make more resources available for sanctuary and stronghold basins, uninvited government designations of “sanctuary” or “stronghold” status risk driving local communities away from the sanctuary concept. There will have to be careful efforts to build trust and integrate the needs and interests of local communities. Creative incentives and community outreach efforts will be needed to convert wild salmon populations from regulatory burdens to valued community assets. (Source: Guido Rahr, Wild Salmon Center.)