HATCHERY SCIENTIFIC REVIEW GROUP

Puget Sound and Coastal Washington Hatchery Reform Project

HATCHERY REFORM

Report to Congress

March 2006

Introduction

This document contains the annual report to Congress from the Hatchery Scientific Review Group (HSRG) and Long Live the Kings (LLTK) on the *Puget Sound and Coastal Washington Hatchery Reform Project*. The report begins with a chapter from the HSRG entitled *Necessary Ingredients for Hatchery Reform.* This is intended to provide the state, tribal and federal salmon and steelhead managers (Washington Department of Fish and Wildlife or WDFW, Northwest Indian Fisheries Commission or NWIFC, National Oceanic and Atmospheric Administration/National Marine Fisheries Service or NOAA Fisheries, and US Fish and Wildlife Service or USFWS) with a succinct outline of criteria for tracking whether key elements of hatchery reform are being implemented.

Following this are chapters detailing project accomplishments in 2005 and work in progress for 2006. The report concludes with a series of appendices providing more detail on expenditures, activities and communications in 2005; a project budget for 2006; and background on some of the key scientific concepts that underlie the findings of the HSRG and this approach to reforming how hatcheries—and salmonids—are managed.

These key concepts—and early efforts by the state and tribal co-managers to implement them—were presented at an October 2005 conference in Seattle entitled *Hatchery Reform: Managing for Success* (see Communications section of 2005 Accomplishments). Much of the detail from that conference is captured in the conference summary, attached as a separately bound publication and/or available electronically from the project's web site.

More information on this report, on the Hatchery Reform Project, and all project publications are available at:

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The Necessary Ingredients for Hatchery Reform

The HSRG has developed a set of criteria for determining whether key elements of hatchery reform are being implemented in the region. The principal requirements for operating hatcheries consistent with resource goals are a **Scientific Framework** and an **Information Sharing System.** These requirements are described in more detail below. During the coming year, the HSRG will ask the co-mangers to report on progress in these areas. Their responses will be a part of the HSRG's 2006 Report to Congress.

1) A transparent and actively maintained **Scientific Framework**[1] should include:
   a) Explicitly stated, comprehensive, scientifically-defensible biological premises[2] to support decision making.
   b) A research plan to address key uncertainties in the Framework.
   c) A formal procedure to periodically update the Framework.
2) **An Information Sharing System**[3] that provides real time access[4] to reliable information about goals, actions and outcomes at the Evolutionarily Significant Unit (ESU), regional and stock-specific levels. Specifically, for each stock, by region and by ESU, the following should be provided:
   a) A **Comprehensive Strategic Plan** that answers the questions: *Where are we currently? Where do we want to be in the future*?
      i) *What is current status of harvest and conservation?*
         (1) What has been the recent *management intent*[5] for the stock?
         (2) What is the current average number and composition of the natural spawning escapement?
         (3) What is the current average number and composition of the hatchery escapement?
         (4) What is the current average contribution to each fishery from the stock (by hatchery and natural components)?
      ii) *What is the current condition of habitat, harvest, and hatcheries*?
         (1) What has been the recent *management strategy*[6] for the stock?
         (2) What is the estimated capacity and productivity of the habitat available to the stock?

[1] The Scientific Framework developed by the HSRG should serve as the starting point
[2] The biological premises should include detailed assumptions (models) about genetics, ecology, physiology, behavior and fish health, as they relate to the effects of hatchery production.
[3] The Managing for Success system, including the All-H Analyzer (AHA) calculator, is being designed to meet this need.
[4] Different levels of access should be available for different user groups, e.g., regional managers will have access to more detailed and provisional information, whereas public users should have access to summary information that meets defined quality criteria.
[5] The *management intent* describes goals for harvest, conservation and/or education.
[6] The *management strategy* describes how habitat, harvest and hatchery management will contribute toward goals.

(3) What is the average exploitation rate for the stock (by hatchery and natural components)?
(4) If there is a hatchery associated with the stock, what is: its purpose (harvest and/or conservation), type (segregated or integrated), size (number of broodstock and number of juveniles released), broodstock composition (percent natural-origin recruits or NORs), reproductive success (recruits per spawner), and *stray rate*[7]?

iii) *What is the long-term goal for harvest and conservation?*
(1) What is the long-term *management intent* for the stock?
(2) What is the target number and composition of the natural spawning escapement?
(3) What is the long-term goal for composition of the hatchery escapement?
(4) What is the target contribution to each fishery from the stock (by hatchery and natural components)?

iv) *What is the target future condition for habitat, harvest, and hatcheries*?
(1) What is the long-term *management strategy* for the stock?
(2) What is the estimated capacity and productivity of the habitat available to the stock?
(3) What is the targeted average exploitation rate for the stock (by hatchery and natural components)?
(4) If there will be a hatchery associated with the stock, what will be: its purpose (harvest and/or conservation), type (segregated or integrated), size (number of broodstock, and target number of juveniles to be released), broodstock composition (percent NORs), reproductive success (recruits per spawner), and expected stray rate?

b) **An Overview of Actions** targeting or affecting the stock. What habitat, harvest, and hatchery actions are completed, under way or planned to move toward the long-term goals? For example, for each hatchery action provide:
i) A description of how and to what extent the action will affect goals for harvest and/or conservation (including action objectives in terms of response variables and measurable indicators).
ii) An action plan (milestones and schedule).
iii) The cost of each phase of the action.
iv) The status of each phase of the action and the identity of the individual responsible (for management of time, quality and human resources).
v) The action categories (e.g., cost, "action type," others).
vi) An action priority rating relative to goals for harvest and/or conservation (at the stock, regional and ESU levels).

c) **A Summary of Outcomes**. Collect and display empirical information that shows if actions are correctly implemented and effective, and if progress is made toward long-term goals for harvest and conservation. This information would be shown in tables and/or simple graphs that also show targets and goals.
i) Is the action plan fully implemented as intended? For example, if the action was to integrate natural fish into the hatchery broodstock, was the target number of broodstock and broodstock composition (NORs vs. hatchery-origin recruits or HORs) achieved? Was the targeted number of juveniles released?
ii) Is the action effective—are actions resulting in expected changes in effectiveness indicators? Specifically, show:
(1) composition of natural spawners (NORs vs. HORs).
(2) stray rates.

[7] The term *stray rate* as used here means the fraction of returning HORs that does *not* return to the hatchery.

(3) distribution of natural spawners (NORs vs. HORs).
(4) number and size of fish contributing to each fishery.
(5) biological traits of adult returns (NORs vs. HORs).
(6) reproductive success in the natural environment (recruits per spawner).
(7) reproductive success in the hatchery environment (recruits per spawner).
(8) biological traits of hatchery fish released.
(9) biological traits of naturally produced juveniles.

iii) How is the stock responding over time? Specifically, show:
(1) time trends in estimated natural escapement abundance.
(2) time trends in composition (NORs vs. HORs) in natural escapement.
(3) time trends in diversity of the natural stock.
(4) time trends in productivity (recruits per spawner) in the natural environment.
(5) time trends in estimates of the productivity and capacity of the natural environment.
(6) time trends in harvest by fishery of NORs and HORs.
(7) identify other species and stocks potentially affected by this stock (link to those stocks in the database).

2005 Accomplishments

TECHNICAL DISCUSSIONS/TOOL DEVELOPMENT

Following up on a series of technical discussions in 2004 that led to the refinement of hatchery reform principles and the development of prototype decision-support tools, HSRG and co-manager scientists and technical staff participated in bi-monthly technical discussions from April through December 2005 on key topics relating to implementing hatchery reform. These topics included refinements to the All-H Analyzer (AHA) and Managing for Success (MFS) tools discussed below; developing a hatchery research agenda (see Appendix E); considering ecological interactions between hatchery and wild fish; and reviewing the products of the co-managers' Risk Assessment Management Project (RAMP).

LLTK facilitated, coordinated, provided conference calling and desktop sharing, and maintained a technical discussions web site as a repository for background materials and working drafts. This facilitated the exchange of information and allowed co-managers from across the Puget Sound and coastal Washington region to participate in the technical discussions.

State, tribal and HSRG scientists developed and tested AHA during technical discussions and regional technical workshops in 2004 (the tool is described in more detail in last year's report to Congress). AHA helps managers explore the likely results of alternative habitat, harvest and hatchery actions and strategies, putting the three "H's" on one page. AHA allows users to apply a scientific approach in the face of the uncertainty always present in natural resource management. AHA fosters accountability, by documenting goals, assumptions, hypotheses, management decisions and the rationale behind these decisions.

AHA is now being used by managers throughout Washington state and on the Columbia River. But there is still need for a practical and cost-effective tool that helps managers monitor, evaluate and adaptively manage salmon and steelhead programs, to ensure they are successful and accountable for results. The HSRG and co-manager scientists worked throughout 2005 to develop such a tool, MFS. MFS will:

- Feature a publicly-accessible, user-friendly web site where decision-makers, technical personnel and other stakeholders can access information, make queries, generate reports, analyze trends, prioritize projects and determine if goals are being met.
- Answer key management questions, while simplifying and/or automating routine management tasks, so that both decision-makers and technical staff have incentive to maintain the system. In this way, it will be both "top down" and "bottom up."
- Answer questions like: "Where are we now? Where are we going? How are we doing? Have we done what we set out to do? Are we getting the expected responses? What will proposed actions cost? What changes do we need to make to reach our goals?"

MFS is available online as a prototype (www.mobrand.com/mfs; log in with user name "public" and password "public"), including hatchery actions and outcomes datasets for Puget Sound and coastal Washington, from the Hatchery Reform Project. When the MFS interface is completed, managers will have a complete set of scientific framework, recommendations and tools for implementing hatchery reform and the new approach to salmon and steelhead management.

LLTK, the HSRG, WDFW, the Northwest Power and Conservation Council and others have begun demonstrating the tools for various interested parties. USFWS—with facilitation assistance from LLTK—is applying AHA, MFS and other Hatchery Reform Project principles and tools in a review of hatchery programs it owns or operates on the Columbia (see USFWS Work in Progress section). WDFW has committed to using AHA to evaluate all stocks it manages and finalizing, hosting and maintaining MFS (see WDFW Work in Progress section).

RESEARCH AND SCIENTIFIC PUBLICATIONS

The HSRG continued in 2005 to oversee a competitive grant program to fund research projects that fill knowledge gaps about using hatcheries to meet harvest and/or conservation goals. In February, the HSRG held its annual research review meeting at the NOAA Sand Point Auditorium in Seattle, receiving reports from funded researchers. Following this review, the HSRG decided to continue funding for two projects: Hamma Hamma Steelhead and Snow Creek Coho.

In June, an HSRG essay entitled *Hatchery Reform in Washington State: Principles and Emerging Issues* was published as the feature article in *Fisheries*, the magazine of the American Fisheries Society (see Appendix K). The HSRG is working on manuscripts providing greater detail on several of these emerging issues in hatchery reform. Those will also be submitted to peer-reviewed journals (see section on HSRG Work in Progress).

As mentioned above, the HSRG worked with co-manager scientists during 2005 technical discussions to develop hatchery research priorities. The HSRG's resulting technical discussion paper on the topic is attached as Appendix E.

AGENCY SCIENCE TEAMS

(Information below provided by the Washington State Department of Fish and Wildlife)

A central 2005 hatchery reform accomplishment for the WDFW hatchery science team was participating in the development of the MFS tool (see above). Ensuring compatibility with MFS required modifications to existing methods and types of data collected at WDFW hatcheries. WDFW began developing a web-based, hatchery data management application that incorporates the documentation of hatchery broodstock integration/segregation plans and allows remote WDFW fish rearing facilities to organize fish rearing information, and share data with each other and WDFW's Olympia headquarters. The initial emphasis has been on organizing hatchery data, with a secondary effort to organize various related data sets presently maintained by headquarters staff. This work is expected to continue through 2006–07.

WDFW science staff also evaluated WDFW Chinook and coho hatchery programs in Puget Sound, the coast and the Columbia River regions using the AHA tool, to determine current levels of integration/segregation, and outline potential program modifications to move the programs toward HSRG guidelines. This review resulted in the development of integration/segregation broodstock management plans for six Chinook and one coho program in Puget Sound (Kendall spring Chinook; Marblemount spring, summer and fall Chinook; Issaquah fall Chinook; Wallace summer Chinook and coho) and three coho programs on the Columbia River (Elochoman, Washougal, Kalama; while these Columbia River programs are outside the scope of the HSRG review, WDFW felt that applying HSRG recommendations to the Columbia will aid in the use of WDFW hatcheries for recovery of listed populations in this region). The Chinook plans are now being discussed with the co-managers for implementation in fall 2006.

To lessen potential impacts to listed fish and comply with HSRG recommendations, some hatchery programs were reduced or eliminated. The Elwha Hatchery Chinook program was reduced from 3.85 million to 2.7 million fish. The Hoodsport Hatchery Chinook program was reduced from three million to 2.8 million fingerlings, and from 250,000 to 120,000 yearlings. The Big Beef Chinook program of 200,000 sub-yearlings was eliminated. Coho programs were reduced at George Adams and Soos Creek hatcheries. There were also reductions in steelhead, chum and pink salmon hatchery programs.

Hatchery equipment needed to integrate hatchery broodstocks and increase efficiency was acquired at several hatcheries. These included rearing tanks, broodstock stunning machines, fish pumps, dewatering towers, and an automated snout snipper for coded-wire tag recovery. Ongoing major hatchery renovations, as per HSRG recommendations, include Skookumchuck Hatchery and Palmer Rearing Ponds.

(Information below provided by the Northwest Indian Fisheries Commission)

Tribal hatchery reform funding not devoted to implementation projects at tribal facilities (see below) has been used to support the tribal hatchery science team within the Enhancement Services Division at NWIFC, as well as the tribal representative to the HSRG, based at the Nisqually Tribe. The NWIFC hatchery reform-funded science team consisted of a geneticist, a biometrician and a salmon ecologist, who are supervised by a senior geneticist. The geneticists provided technical support for commission and tribal staff on issues involving genetics and salmon recovery including: appropriate uses of hatcheries in salmon recovery programs; planning, implementation and monitoring of hatchery research; risk assessment; and mixed stock fishery analysis using genetic data. The salmon ecologist provided technical support for tribal programs on issues involving ecology and artificial production such as the role of fish behavior, interspecies interactions and freshwater and nearshore habitats in designing hatchery programs; planning, implementation and monitoring of research for hatchery activities; and risk assessment of hatchery programs. The biometrician provided technical support for NWIFC and tribal enhancement staff on experimental design and monitoring, statistical analysis and database maintenance.

FY 2005 tribal science team work activities:

- NWIFC staff geneticists worked with tribes on genetic issues associated with the development of hatchery management and reform plans; helped collect and analyze morphological and DNA data

on all Puget Sound Chinook and Lake Ozette sockeye; developed tribal research to evaluate genetic changes in hatchery and wild populations; helped the Tulalip Tribe establish its genetics laboratory for monitoring its hatchery programs; reviewed proposals for reintroducing salmon to areas in the Puget Sound where they had been extirpated; reviewed proposals for new hatchery programs in the Nooksack and White rivers; provided technical expertise to the HSRG in the continuing development of the AHA tool and in identifying research priorities for hatchery reform; coordinated information exchange between the co-managers, the HSRG, other independent scientific review groups such as the Recovery Science Review Panel, federal regulatory agencies, and the Shared Strategy for Salmon Recovery in Puget Sound; and developed the only probabilistic quantitative models available to assess genetic and ecological risks of hatchery programs.

- The NWIFC staff biometrician worked with the tribes to develop statistical techniques for assessing the contribution of hatchery and wild fish to natural spawning aggregations; analyzed data on returns of hatchery fish, which is useful for evaluating the success of hatchery programs; and provided statistical consulting on tribal research and monitoring projects. The biometrician has assisted the HSRG in developing monitoring and evaluation criteria that can be used to determine the success of a hatchery program in meeting its goals and objectives. These criteria will also consider what data is needed for future research on hatcheries. The biometrician worked individually with tribes in the different regions to tailor monitoring and evaluation criteria to the features and circumstances of their region.
- The NWIFC salmon ecologist helped tribes develop and implement estuary research for investigating co-occurrence between hatchery and wild fish; expanded the acoustic tracking study of juvenile salmon migration initiated by the tribes to a multi-agency, Puget Sound effort; continued to build upon a literature database on ecological interactions; and is developing a database of tribal hatchery reform recommendations and completed hatchery reform projects. The ecologist also worked with individual tribes to assist in development and implementation of ecological studies funded through the Hatchery Reform effort.
- New hatchery management software and a database have been developed and distributed, to greatly improve the amount of information available to hatchery managers. The software, called HatPro, improves monitoring, management and planning capabilities for hatchery managers, as well as allowing on-site electronic transfer of key hatchery data directly to state, tribal and federal agencies. Four group training workshops, and numerous on-site training sessions, have been provided to tribal hatchery managers.

Implementation Projects

The goal of tribal hatchery management is to protect, restore and enhance the productivity, abundance, and diversity of salmon and their ecosystems to sustain ceremonial, subsistence, commercial and recreational fisheries, non-consumptive fish benefits and other cultural and ecological values. The purpose of these grants is to promote that goal through hatchery reform by providing financial resources for: 1) scientific support for integrating ecological and genetic factors affecting hatchery success into hatchery management; 2) identifying and developing projects that improve, evaluate, or monitor hatchery practices and strategies; or 3) modifying or constructing hatchery facilities to improve hatchery operations in tribal hatcheries.

To this end, the western Washington Treaty tribes have used hatchery reform funding to: 1) compile and maintain accurate information on tribal programs in hatchery and genetic management plans (HGMPs); 2) employ a team of three scientists at NWIFC to provide scientific support to the tribes for hatchery reform initiatives; 3) develop and award funding for hatchery reform projects through a rigorous process to solicit, develop and evaluate proposals; and 4) coordinate with NOAA Fisheries and the HSRG to ensure that tribal hatcheries programs pose no jeopardy to ESA listed species and are consistent with the intended management goals, respectively.

The HSRG's independent review and recommendations of hatchery programs have been an important source of ideas and criteria for hatchery reform proposals and projects. Improvements in the process for developing tribal hatchery reform proposals, including technical review of the proposals by NWIFC scientists and others, has helped maintain competitive balance among proposals from different tribes and is leading to higher quality projects.

In Fiscal Year (FY) 2005, the competitive selection and ranking process resulted in seventeen projects receiving tribal hatchery reform funding for a total funding amount of $535,610. Twelve of these projects focused on improving, evaluating or monitoring hatchery practices (Type I projects), for a cumulative funding amount of $428,362. Five tribal hatchery reform projects received funding to improve tribal hatchery facilities and operations (Type II projects), for a cumulative cost of $107,248.

The majority of funded projects focused on Chinook salmon (*Oncorhynchus tshawytscha*), which is listed under ESA. This reflects the high priority given to projects associated with salmon recovery in the project ranking process and the importance of this species to the tribes. The largest portion of projects funded to improve hatchery practices (Type I) focused on adult abundance and contribution monitoring, followed by projects to develop and/or improve baseline genetic data for broodstock selection and monitoring. Other projects focused on evaluating rearing and release strategies and critical knowledge gaps in understanding juvenile production, habitat use and interactions between hatchery and wild fish. Type II projects allowed tribal programs to upgrade facility structures and equipment, allowing for improved operational efficiency and management options.
Appendix C summarizes funded projects by rank order, respective of project type and associated project cost, and then provides greater detail on each project. The table below provides the number and description of tribal hatchery reform projects funded for FY 2005.

Project Type	Number of Projects Funded	Project Description Category
I	2	Broodstock choice, juvenile rearing and release strategies
I	5	Adult abundance and contribution monitoring
I	2	Hatchery / wild juvenile production and habitat use
I	3	Genetic monitoring and characterization
II	5	Hatchery facility improvements

(Information below provided by the US Fish and Wildlife Service)

FY 2005 USFWS science team work activities included:

- Participation of a USFWS fish geneticist as a member of the HSRG, including preparation of reports and scientific papers.
- Implementing HSRG recommendations at Quilcene, Makah and Quinault NFHs.
- Participation in a USFWS Hatchery Review Working Group that designed a process for applying the HSRG's principles, tools and recommendations to all USFWS facilities on the Columbia (see section on USFWS Work in Progress).

COMMUNICATIONS AND OUTREACH

Progress Report to Congress

In April, the HSRG and LLTK provided Congress with an annual report on hatchery reform implementation. The report includes the HSRG's synopsis and evaluation of state, tribal and federal regional progress updates. While emphasizing the overall good progress made by the co-managers, the HSRG reiterated the necessity of both systemic reform and specific improvements in a watershed context.

Regional Salmon Management Processes

Throughout 2005, LLTK and subcontractors Gordon Thomas Honeywell helped the co-managers reach consensus on changes to salmon management documents and processes through which they can implement hatchery reform. This included serving on the Development Committee of the Shared Strategy for Salmon Recovery in Puget Sound and facilitating regional co-manager decision-making meetings (most actively in the Stillaguamish/Snohomish, Hood Canal and South Sound regions). Included in the appendices are letters from WDFW Director Jeff Koenings to the chairs of the Puget Sound and coastal Washington tribal chairs (Appendix H) and to Shared Strategy for Salmon Recovery in Puget Sound chair Bill Ruckelshaus (Appendix I) about each of these processes.

Hatchery Reform Conference

In October, LLTK sponsored and coordinated *Hatchery Reform: Managing for Success*, a day-long conference held in Seattle. The Mountaineers (one of the Northwest's oldest and largest conservation organizations) hosted the conference and provided the meeting facilities. The event highlighted the independent scientific recommendations and co-manager implementation actions resulting from the Puget Sound and Coastal Washington Hatchery Reform Project. Joint presentations by WDFW, treaty Indian tribes, and the HSRG included the role of hatcheries, and hatchery reform in the future of salmon recovery and sustainable fisheries. Conference attendees included congressional and other federal agency officials and staff; legislative and gubernatorial officials and staff; tribal officials and staff; state and tribal agency representatives; and scientific, academic, fishing, and environmental representatives. The conference was cablecast by TV-W, the public access channel of Washington state government. A summary document is attached separately as Appendix L and/or available from

the project's web site. Included in Appendix J is a letter from WDFW Director Jeff Koenings to all WDFW staff about the conference.

Hatchery Reform Coalition

LLTK has convened a coalition of organizations to build a constituency for hatchery reform. The Hatchery Reform Coalition includes organizations that are not always on the same side on all issues, but all have agreed that the HSRG's principles and recommendations represent the right way to proceed with managing the hatchery system. The Mountaineers, Northwest Sportsfishing Industry Association, Puget Sound Anglers, Recreational Fishing Alliance, Trout Unlimited, Wild Steelhead Coalition and other recreation, sports fishing and conservation organizations have signed letters of support for hatchery reform as recommended by the HSRG. The Coalition now features 20 regional and national organizations and advocates, with a combined membership base greater than 300,000. LLTK coordinated and facilitated meetings approximately every other month during 2005, where Coalition members received presentations from state, tribal and federal managers on topics central to hatchery reform.

Other Communications/Outreach

Throughout 2005, LLTK worked with the HSRG and the co-managers to implement a strategy for communicating Hatchery Reform Project background, activities and progress to federal, state, tribal, regional and local stakeholders (see Appendix B for more detail). This included providing briefings for legislators, agency managers and their staffs; making presentations at a wide range of venues; authoring or being interviewed for articles on the project for mainstream and stakeholder media publications; keeping project communication materials (such as the project overview sheet, website and PowerPoint presentation) updated; and many other activities. Preparing for the Hatchery Reform Conference in October 2005 (see above) also required a concerted communications effort.

2006 Work in Progress

HSRG WORK IN PROGRESS

The HSRG has drafted a Scientific Framework, reviewed all hatchery programs in the study area, and helped develop some of the tools needed for successful implementation of hatchery reform. In the coming year, the HSRG will help guide effective implementation, continue tool development, bring hatchery reform concepts to the scientific literature, and review progress by the co-managers. Specific objectives for 2006 are:

1. *Tool Development*: Identify additional funding for continued development and populating the analytical tools—Managing for Success (MFS) and All-H Analyzer (AHA).

2. *Grant Program*: Establish a grant program using HSRG funds to help implement hatchery reform demonstration projects.

    a. Develop criteria for prioritizing demonstration projects.

    b. Develop process for soliciting demonstration projects.

    c. Select and fund demonstration projects.

    d. Review progress on projects.

3. *Scientific Publications*: Prepare three scientific papers for publication.

4. *Long-Term Hatchery Reform Implementation*: Support development of long-term hatchery reform programs by state, tribal and USFWS managers.

5. *Columbia Basin Program*: Identify funding to expand hatchery reform to the Columbia that will replicate the Puget Sound and coastal Washington hatchery reform process.

The HSRG's budget for 2006 is included in Appendix D.

CO-MANAGERS WORK IN PROGRESS

(Information below provided by the Washington State Department of Fish and Wildlife)

WDFW continues to develop integration/segregation broodstock management plans for remaining WDFW Chinook and coho programs in Puget Sound, the Washington coast and the Columbia River. These include Green River, Voights Creek, Deschutes, Minter Creek, Garrison, Elwha and Skokomish fall Chinook, and Dungeness spring Chinook. For Puget Sound, these plans will be presented to the co-managers for discussion, modification and agreement, with anticipated implementation to occur in

fall 2006. Draft plans for the remaining eight coho programs in Puget Sound are in development. In addition, WDFW will be working with others as the HSRG process is duplicated within the Columbia River Basin.

Recognizing that a staged, prioritized and incremental approach to hatchery reform is necessitated by funding, logistical and environmental constraints, WDFW has embarked on a multiyear effort to transform hatcheries from an "all-H risk factor" to a productive tool for restoring salmon and enhancing fishing opportunities. The expected benefits are substantial—enhanced fishing opportunities, improved stock status, economic stimulation of rural communities, and a reduced risk of third party litigation.

Building upon the broad consensus emerging from the independent reviews of hatchery programs conducted by the HSRG (Puget Sound and Washington coast) and Artificial Production Review and Evaluation or APRE (Columbia Basin), WDFW has developed a strategic initiative entitled *Salmon and Steelhead for the 21st Century: Salmon Recovery, Hatchery Reform and Sustainable Fisheries*. This initiative will build the foundation for scientifically defensible programs, implement priority actions to improve hatchery programs, and assure continued program modifications through results-oriented, performance-based management. WDFW has asked LLTK to provide facilitation, communications and strategic planning assistance for this initiative (see LLTK Work in Progress section).

(Information below provided by the Northwest Indian Fisheries Commission)

Because Congress did not provide any funds to the Tribes for continued scientific expertise and implementation of hatchery reform in 2006, both the salmon ecologist and biometrician position will be eliminated, along with the scientific support for these aspects of hatchery reform. Hatchery reform funding has been greatly appreciated by the tribes, but has always been less than the amount needed. Inadequate funding remains the single biggest obstacle to hatchery reform. As quality proposals for hatchery reform projects continue to increase in response to the review and recommendation process, available funding has not been adequate to fully implement the hatchery reform initiative. Ultimately, inadequate funding means that sacrifices in the ability to protect and restore productive salmon runs will lead to sacrifices in legally mandated benefits of tribal hatcheries.

USFWS WORK IN PROGRESS

(Information below provided by US Fish and Wildlife Service)

In addition to continued participation of a USFWS fish geneticist on the HSRG and implementing HSRG recommendations at its three western Washington hatchery facilities, the US Fish and Wildlife Service (USFWS) is beginning a three-year review of the 21 Columbia River Basin salmon and steelhead hatcheries that USFWS owns or operates. The goal is to ensure that USFWS hatcheries are operated on the best scientific principles, and contribute to sustainable fisheries and the recovery of naturally-spawning populations of salmon, steelhead and other aquatic species of concern.

This internal review will, in many ways, resemble the Puget Sound and Coastal Washington Hatchery Reform Project, which USFWS believes provides both a solid template and operational tools (e.g.

software spreadsheets, population dynamic models) for reviewing USFWS hatcheries in the Columbia River Basin. USFWS also believes that much of the background information necessary for reviewing hatcheries in the Columbia Basin has already been compiled in Hatchery and Genetic Management Plans (HGMPs), Comprehensive Hatchery Management Plans (CHMPs) and the APRE database developed by the Northwest Power and Conservation Council (NWPCC).

Based on the recommendations of the USFWS Pacific Regional Office Hatchery Review Working Group (Working Group), the Assistant Regional Director for Fisheries (ARD) has assembled a Columbia Basin Hatchery Review Team (Review Team). This Review Team, comprised of USFWS and other federal agency scientists, has adapted the HSRG's scientific framework, principles and hatchery review tools and is applying them to create reform recommendations for each hatchery program. The team provides excellent continuity with the HSRG because two members (including the chair) have served on the HSRG, the vice chair has served on the policy-makers' Hatchery Reform Coordinating Committee, and three other members represented USFWS at HSRG regional review meetings. USFWS has contracted for project facilitation with LLTK, which has provided facilitation, communications and coordination for the Puget Sound/Coastal Washington process.

The Fisheries ARD has appointed a Hatchery Oversight Team (Oversight Team) to succeed the Working Group as USFWS' primary internal mechanism to oversee the review process, monitor its progress, and transmit communications and reports from the Review Team to the ARD and project leaders within the USFWS Pacific Region Fisheries Program. The Oversight Team is coordinated by the Pacific Region Hatchery/Science Team Leader and includes participation by line supervisors within the Fisheries Program. The Oversight Team, along with the ARD, will be the primary contact group between USFWS and its partners, to develop policies for implementing or modifying the Review Team's recommendations.

The process began in October 2005 with a review of the Warm Springs National Fish Hatchery (NFH) on the Warm Springs River in the Deschutes River watershed/Columbia Plateau province in Oregon. This review is being conducted as a pilot, to help USFWS test and refine the review process. Fishery co-managers and stakeholders are involved in the review process and have been asked to comment on draft reports and recommendations. The Warm Springs NFH report will be published in spring 2006, following co-manager and stakeholder/public review and comment periods.

Following this pilot review, USFWS will adjust the process as necessary and then review three more regions, including three NFHs in the Mid-Columbia region (Leavenworth, Entiat and Winthrop); five NFHs in the Lower Columbia region (Eagle Creek, Carson, Little White Salmon, Willard and Spring Creek); three NFHs in the Snake River region (Dworshak, Kooskia and Hagerman); and nine federally-owned hatcheries that are operated by the states of Washington, Oregon and Idaho as part of the Lower Snake River Compensation Plan (Lyons Ferry, Tucannon, Irrigon, Lookingglass, Wallowa, Clearwater, McCall, Sawtooth and Magic Valley). USFWS plans to complete reviews of all these facilities by 2008. For more information, visit <www.fws.gov/pacific/fisheries/hatcheryreview/>.

LLTK WORK IN PROGRESS

State, tribal and federal managers have started to turn the HSRG's recommendations into reality. This includes making systemic use of tools like AHA and MFS that enable—for the first time—simultaneous evaluation of the benefits and risks of changes to hatchery, harvest and habitat investments, in order to help return the greatest number of healthy, fit adult salmon to fisheries and the spawning grounds.

In Puget Sound and coastal Washington, a large portion of responsibility for implementing this new approach falls on WDFW. In addition to hatchery reform recommendations, WDFW is facing several other obligations and commitments related to salmon/steelhead recovery and sustainable fisheries that need to be addressed simultaneously.

Recognizing the complex and multiple challenges it faces, WDFW's director and senior leadership has asked LLTK to help them make operational the science-based, ecosystem-focused salmonid management needed to meet these obligations. LLTK has accepted this invitation to help create a framework for institutionalizing reform, and facilitate the transformation of WDFW into an internationally-recognized model for 21st century salmon and steelhead management. LLTK expects this *21st Century Salmon and Steelhead Management* initiative to include:

- Short-, medium- and long-term strategic planning.
- Work plans with measurable benchmarks and methods/assignments for tracking and communicating progress.
- Staff training and technical consultation.
- An effective communication strategy with stakeholders and the public, to ensure transparent decision-making and a broad-based constituency supportive of the dramatic changes ahead.

LLTK will work with senior WDFW management to:

- Develop a cross-agency and cross-discipline WDFW Core Management Team.
- Facilitate the development of internal Departmental plans and processes for ensuring hatchery reform implementation.
- Help WDFW take a leadership role in fostering regional ESA salmon recovery processes that bring together habitat, harvest and hatchery management.
- Help WDFW prepare for participation in watershed-by-watershed co-management meetings with the tribes, communications with user groups, and Pacific Salmon Treaty negotiations.
- Help further develop "all-H" decision-support tools like AHA and a transparent action/outcome tracking and evaluation system (MFS), to demonstrate accountability.
- Communicate hatchery reform and "all-H" integration achievements and plans.
- Improve communications with the Washington Fish and Wildlife Commission, and between the different divisions in charge of science, hatcheries, habitat and harvest.

- Help identify and secure resources and expertise.
- Develop a comprehensive monitoring strategy that is consistent statewide and relevant for each region.
- Establish Washington State Government Management Accountability and Performance (GMAP) reporting criteria.

LLTK will also continue in 2006 to build a constituency for new fisheries management and beneficial roles for hatcheries, broadening the base of support among sports and commercial fishermen, environmental organizations, and state and federal legislators and other elected officials. This is critical to ensure reforms get implemented. It is also necessary to ensure that the traditional constituencies for WDFW and the tribes understand why the co-managers are making the changes they are, some of which will be dramatic. Methods for broadening this support will include:

- Coordinating and expanding the Hatchery Reform Coalition.
- Maintaining the <www.hatcheryreform.org> website.
- Taking advantage of other communications opportunities, such as briefings, conference and symposia presentations and newsletters.

LLTK's intended expenditures for this initiative are included in Appendix D. LLTK will supplement the federal funds provided for this initiative with private and foundation funding. In addition, LLTK will continue providing facilitation in 2006 for USFWS' Columbia Basin Hatchery Review (see USFWS Work in Progress section). That work is supported by a separate contract with USFWS.

Appendices

A: 2005 Expenditures

Puget Sound and Coastal Washington Hatchery Reform Project Expenditures	FY 2005
Hatchery Scientific Review Group	
HSRG Members, Travel, Meeting Expenses	$335,000
Research Grants	$125,269
SUBTOTAL	***$460,269***
Washington Department of Fish and Wildlife	
Agency Staffing HSRG member; HSRG support staff; hatchery biologist	$175,000
Hatchery Database Development and Managing for Success Initiative	$100,000
Hatchery Broodstock Integration/Segregation Plan development and implementation, equipment	$100,000
Coded-wire Tagging Chinook and Coho	$355,000
Hatchery New Technology Equipment	$50,000
Hatchery Monitoring and Evaluation Fish counting, recovery of tagged experimental fish, spawning surveys; downstream enumeration, predator control, electronic tag detection, various experiment follow-ups.	$31,000
SUBTOTAL	***$801,000***
Northwest Indian Fisheries Commission	
HSRG Member	$39,031
NWIFC Support Staff	$242,206
Improve, Monitor and Evaluate Hatchery Practices Type I projects at Stillaguamish, Makah, Tulalip, Quileute, Squaxin Island, Skagit River System Cooperative, Nooksack, Port Gamble and Lower Elwha	$428,362
Improve Hatchery Facilities Type II projects at Tulalip, Stillaguamish, Makah, Nisqually and Quinault	$107,248
SUBTOTAL	***$816,847***
US Fish and Wildlife Service	
Science Team	$70,550
Management, Accountability and Demonstration Projects	$41,500
SUBTOTAL	***$112,050***
NOAA Fisheries	
Science Team	$70,550
Long Live the Kings	
Project Coordination, Facilitation, Communications	$238,118
Subcontracts (Gordon Thomas Honeywell)	$175,000
Hatchery Reform Conference (*does not reflect full costs; LLTK supplemented from other sources*)	$31,882
SUBTOTAL	***$445,000***
Budget Administration	
Interagency Commission for Outdoor Recreation	$34,000
US Fish and Wildlife Service	$34,731
SUBTOTAL	***$68,731***
FY 2005 TOTAL	**$2,774,447**

B: 2005 Communications

OUTREACH	
Recreational Fishing Alliance January 4, 2005	LLTK Executive Director Barbara Cairns, Jim Waldo of Gordon Thomas Honeywell and LLTK Project Director Michael Kern met with Corey Freeman, who at the time represented the Recreational Fishing Alliance on the Hatchery Reform Coalition.
Briefing for Environmental Leaders January 6, 2005	Barbara Cairns and Michael Kern hosted a small gathering of key environmental leaders, to ensure they had a full understanding of the Hatchery Reform Project, update them on recent progress and discuss the project's next steps.
Steelhead and Cutthroat Policy Advisory Group January 12 & 21, 2005	HSRG Vice Chair Lee Blankenship presented to this WDFW advisory committee in Olympia on the HSRG's system-wide recommendations for steelhead. HSRG member Paul Seidel and WDFW's Andy Appleby led a follow-up workshop featuring case studies applying the All-H Analyzer (AHA) to steelhead stocks.
Wild Salmon Center January 25, 2005	Barbara Cairns and then-LLTK Director of Project Development Betsy Daniels met with Elliott Marks, who was directing a project for the Wild Salmon Center, to introduce him to the Hatchery Reform Project. Shortly thereafter, he was named Natural Resources Advisor to Washington Governor Christine Gregoire.
Shared Salmon Strategy for Puget Sound Summit January 26, 2005	HSRG Chair Lars Mobrand participated in the hatchery break-out session of this conference in Tacoma. LLTK reviewed and edited the "platform statement" for that session.
Hatchery Reform Coalition February 17, 2005	LLTK coordinated this meeting held to discuss how hatchery reform fits into other salmon recovery processes, the Washington State Department of Fish and Wildlife (WDFW) biennial budget submission, and hatchery reform beyond 2005.
Adaptive Management Workshop February 28 & March 1, 2005	LLTK Fish Program Coordinator Michael Schmidt participated in a workshop in Seattle co-hosted by Washington Trout, Seattle Public Utilities and Shared Strategy on applying adaptive management to salmon recovery in Puget Sound.
WRIAs 7–10 Technical Committees March 3, 2005	Michael Kern worked with King County staff to coordinate a workshop on AHA for WRIAs 7–10. Paul Seidel and Andy Appleby conducted the workshop.
Hatchery Reform Coalition March 21, 2005	LLTK coordinated this meeting held to discuss how hatchery reform was reflected in the WDFW biennial budget submission.
Hatchery Reform Coalition April 12, 2005	LLTK coordinated this meeting held to review the purposes of the Hatchery Reform Project and the Coalition.
Cedar River Anadromous Fish Committee Presentation April 25, 2005	Michael Kern provided an overview and update on the Hatchery Reform Project to this committee chartered as part of the City of Seattle's Habitat Conservation Plan for the Cedar River.
Steelhead Summit Alliance May 14, 2005	Michael Kern provided an update on the Hatchery Reform Project in Bellevue at the spring meeting of this informal network of west coast steelhead groups.
Department of Fisheries and Oceans-Canada (DFO) June 22, 2005	HSRG Vice Chair John Barr and member Trevor Evelyn presented the HSRG's principles and recommendations to a team of DFO personnel who were applying those principles and recommendations to DFO's hatchery programs.

Seattle Foundation Community Conversation June 29, 2005	Michael Kern participated in this forum in Seattle, sponsored by the Seattle Foundation, to ensure a hatchery reform perspective was included in the Foundation's new giving priorities for environmental issues.
NOAA Fisheries July 6, 2005	Barbara Cairns and Michael Kern met with NOAA Fisheries policy advisors Todd Ungerecht and Karl Anderson to update them on the Hatchery Reform Project, including the AHA and Managing for Success (MFS) tools.
Hatchery Reform Coalition August 4, 2005	LLTK coordinated this meeting held to receive an update on Hatchery Reform Project activities and a presentation on the US Fish and Wildlife Service's (USFWS) upcoming review of all USFWS-affiliated hatchery programs on the Columbia River.
Northwest Marine Trade Association (NMTA) August 8 & September 12, 2005	Barbara Cairns and Michael Kern met with NMTA's president, vice president and director of fishing affairs in August to introduce the Hatchery Reform Project. This led to an invitation to present to the NMTA Fish Committee in September.
Hatchery Reform Coalition October 19, 2005	LLTK coordinated this meeting held to receive a briefing on the Mitchell Act Coalition and an update on WDFW hatchery reform implementation activities.
Hatchery Reform Conference October 28, 2005	LLTK sponsored and coordinated a conference at the Mountaineers Building in Seattle REI highlighting the independent scientific recommendations and co-manager implementation case studies resulting from the Hatchery Reform Project. The HSRG presented its scientific findings.
Northwest Fish Culture Conference December 6-8, 2005	Hatchery Reform Coordinating Committee member and USFWS Hatchery Review Team Vice Chair Doug DeHart provided an update on the Hatchery Reform Project at this gathering in Boise, ID of Northwest hatchery personnel.
PUBLICATIONS	
All-H Analyzer (AHA) Overview January, 2005	The HSRG and LLTK developed a one-page overview of AHA and sent it to a list of over 300 decision-makers, managers, scientists and stakeholders. It became the basis for an HSRG/Co-Manager technical discussion paper (see below).
Conservation Hatcheries Technical Discussion Paper March 11, 2005	The HSRG publish a technical discussion paper on when to start a conservation hatchery program. It is available from the web site.
Report to Congress April 28, 2005	LLTK sent the 2005 Hatchery Reform Project Report to Congress to 20 members of Congress, Congressional staffers, and others involved in the appropriations process. It included the HSRG's synopsis and evaluation of state, tribal and federal regional progress updates, alongside co-manager and USFWS reports on accomplishments and work in progress.
Shared Salmon Strategy for Puget Sound Recovery Plan June, 2005	LLTK provided edits to the Regional Hatchery Strategy, H-Integration, and Adaptive Management sections of this plan, to encourage consistency with the HSRG's principles and recommendations.
Shared Salmon Strategy for Puget Sound E-Bulletin October 19, 2005	This email bulletin included the Hatchery Reform Conference announcement.
***Fisheries* Magazine Essay** June 2005	The HSRG authored *Hatchery Reform in Washington State: Principles and Emerging Issues,* as the feature article in the American Fisheries Society's peer-reviewed journal. It is available from the web site.

AHA Technical Discussion Paper August, 2005	The HSRG and co-manager scientists published a technical discussion paper on AHA. It is available from the web site.
Managing for Success (MFS) Overview October, 2005	The HSRG developed a one-page overview of MFS, for inclusion in the Hatchery Reform Conference meeting materials.
Hatchery Reform Project Update Sheet	LLTK revised a four-page update on the Hatchery Reform Project in January and May, for use throughout the year and on the web site.
Hatchery Reform PowerPoint	Throughout the year, LLTK kept the project's PowerPoint presentation up to date and tailored it for the various audiences to whom HSRG members and LLTK staff made presentations.
LLTK and Hatchery Reform Project Web Sites (www.lltk.org, www.hatcheryreform.org)	Throughout the year, LLTK kept this site up to date, providing electronic access to information about the projects and publications including reports, meeting summaries and background information. LLTK added and maintained a background/draft documents page for the HSRG/Co-Manager Hatchery Reform Technical Discussion Group.
Hatchery Reform Coalition Overview/Membership List	Throughout the year, LLTK kept up to date a one-pager overview of the Hatchery Reform Coalition and its membership. It is available from the web site.

C: 2005 Tribal Implementation Projects

(Type I projects evaluate, improve or monitor hatchery practices; Type II projects retrofit, modify or build facilities)

Type	Sponsor	Project Title	Cost	Cumulative Cost
I	Stillaguamish	Stillaguamish Chinook Smolt Production Estimation-Characteristics of Hatchery & Wild Contributions	$32,601	$32,601
I	Makah	Umbrella Creek Sockeye Adult Escapement Monitoring and Brood Stock Capture	$46,394	$78,995
I	Tulalip	Assessment of the Contribution of Tulalip Hatchery Chinook to Terminal Fisheries & Local Spawning Populations Using Otoliths	$29,088	$108,083
I	Makah	Lake Ozette Calcein Marking and Monitoring	$28,420	$136,503
I	Quileute	Coded-wire Tag Study of Sol Duc Native Summer Chinook	$13,574	$150,077
I	Squaxin Island	Acoustic Tagging & Tracking of Squaxin Island Coho, Hammersley Inlet Wild Salmon and Percival Cove Chinook	$34,554	$184,631
I	Skagit River System Coop	Evaluation of the Need to Continue Both the Fall and Summer Chinook Hatchery CWT Releases in the Skagit River	$57,623	$242,254
I	Nooksack	South Fork Nooksack River Smolt Outmigration & Tissue Sampling Project	$40,775	$283,029
I	Port Gamble	North Hood Canal Coho Straying Study	$51,658	$334,687
I	Quileute	DNA Fingerprinting Used to Evaluate the Degree of Introgression Between Native Summer Chinook and Introduced Spring Chinook Stocks in the Sol Duc River	$24,478	$359,165
I	Makah & Lower Elwha	DNA Comparison of Chinook from Pysht, Hoko, & Seiku Rivers	$21,678	$380,843
I	Skagit River System Coop	Identifying Relationships and Exploring Possible Mechanisms That Influence Nearshore Survival Between Hatchery & Wild Chinook in the Skagit River	$47,519	$428,362
		Type I Total		**428,362**
II	Makah	Emergency Oxygen Backup System for Makah Remote Sockeye Rearing Sites	$16,154	$16,154
II	Nisqually	Predator Net System for Kalama Creek Hatchery	$23,540	$39,694
II	Stillaguamish	Emergency Oxygen Backup System for Circular Rearing Tanks at Harvey Creek	$20,439	$60,133
II	Tulalip	Install Bird Net Support Structure in Upper Tulalip Creek Pond (Augment FY 2004 Project Due to Unforeseen Costs)	$28,065	$88,198
II	Quinault	Fish Loading and Transfer Pump	$19,050	$107,248
		Type II Total		**$107,248**
		GRAND TOTAL		**$535,610**

Type I Projects - projects to improve, evaluate or monitor hatchery practices

Tribe: Makah
Name of Project: Umbrella Creek sockeye adult escapement monitoring and broodstock capture
Stock and Status: Lake Ozette sockeye, ESA threatened
Hatchery: Makah National Fish Hatchery, Umbrella Creek Hatchery
Project Benefit: Essential for recovery of ESA listed stock
Project Description: The primary goal of the Umbrella Creek sockeye hatchery program is to establish viable naturally spawning populations in the habitats deemed suitable for sockeye in the Lake Ozette watershed. To determine optimum fish size at time of release in conjunction with different rearing and release strategies, all program fish are differentially thermal marked for subsequent identification using fish otolith recoveries with a subset of fish releases marked with external adipose fin clips. The marking strategy provides a mechanism to evaluate unfed fry, fed fry, and fingerling release strategies and to differentiate hatchery origin adult returns from naturally spawned adult returns. The data collected through this project will allow accurate estimation of hatchery and natural origin contribution rates for the Umbrella Creek sockeye escapement and will provide a basis to systematically collect broodstock that are representative of the entire population.

Tribe: Makah
Name of Project: Lake Ozette sockeye calcein marking and monitoring trial
Stock and Status: Lake Ozette sockeye, ESA threatened
Hatchery: Umbrella Creek Hatchery, Makah National Fish Hatchery, Stony Creek and Elk Lake remote site incubators
Project Benefit: Essential for recovery of ESA listed stock
Project Description: The primary goal of the Umbrella Creek sockeye hatchery program is to establish viable naturally spawning populations in the habitats deemed suitable for sockeye in the Lake Ozette watershed. This pilot-study is to evaluate the effectiveness of calcein as a mass-mark for hatchery reared Lake Ozette sockeye, especially as a non-lethal method to differentiate natural and hatchery origin smolts during outmigration. See above project for further background context.

Tribe: Makah and Lower Elwha
Name of Project: DNA comparison of fall Chinook from the Hoko, Seiku and Pysht rivers.
Stock and Status: Fall Chinook, SASSI depressed
Hatchery: Hoko River Hatchery
Project Benefit: Reintroduction and recovery of historical Chinook populations
Project Description: The goal of this project is to determine the degree of genetic relatedness between Chinook salmon populations in the Hoko, Pysht and Seiku watersheds. Results from this study will facilitate evaluation of the Hoko population as an appropriate source to reestablish fall Chinook in the Pysht and Seiku watersheds, which are historical Chinook habitats.

Tribe: Nooksack
Name of Project: South Fork Nooksack smolt outmigration and tissue sampling
Stock and Status: Native spring Chinook, ESA threatened
Nooksack coho, SASSI unknown
Project Benefit: Essential for preserving critical ESA listed stock

Project Description: The goal of this project is to operate a smolt outmigrant trap to 1) estimate juvenile salmonid abundances, and 2) collect representative Chinook and wild coho salmon tissue samples to genetically determine relative stock compositions while improving basin DNA baselines. This information is critical towards the development of an integrated hatchery recovery program for South Fork early Chinook, in accordance with recovery actions submitted to the Shared Strategy process.

Tribe: Port Gamble S'Klallam
Name of Project: North Hood Canal hatchery coho straying study
Stock and Status: Northeast Hood Canal coho, SASSI depressed
Hatchery: Port Gamble Bay net pens
Project Benefit: Protect genetic resources while allowing for treaty harvest rights
Project Description: The underlying issue with regard to several Hood Canal HSRG recommendations and Co-manger responses to these recommendations is straying of hatchery coho in general and of net pen reared fish in particular. This proposal is to begin a three-year study to evaluate straying of hatchery coho into north Hood Canal streams by intensively sampling coho adults in the fall and juveniles in the spring. The study will be done in collaboration with the USFWS in its investigation of the genetic makeup of regional coho populations.

Tribe: Quileute
Name of Project: Coded-wire tagging to determine contribution of wild and hatchery fish for broodstock management of native summer Chinook
Stock and Status: Sol Duc native summer Chinook, status unknown
Introduced spring Chinook, SASSI healthy
Hatchery: Lonesome Creek
Project Benefit: Preserve genetic integrity of the natural fish population while allowing for treaty harvest rights
Project Description: Proper hatchery management of an integrated program requires accurate identification of returning adult salmon of hatchery versus natural origin for broodstock purposes. This project will allow for proper management of an integrated hatchery program by coded-wire tagging juvenile summer Chinook. Additionally, project funding will be used to execute sampling for adult tag recoveries in the fisheries and on the spawning grounds. This information is necessary for estimation of adult harvest and survival rates and ultimately, evaluation of program success.

Tribe: Quileute
Name of Project: DNA fingerprinting of native summer Chinook and introduced spring Chinook stocks on the Sol Duc River.
Stock and Status: Sol Duc native summer Chinook, status unknown
Introduced spring Chinook, SASSI healthy
Hatchery: Lonesome Creek
Project Benefit: Preserve genetic integrity of the natural fish population while allowing for treaty harvest rights
Project Description: Historically, summer and spring Chinook in the Sol Duc River have coincided in the hatchery and on the spawning grounds despite management goals to segregate these two stocks. Both the Co-managers and the HSRG agree that a better understanding of the current genetic composition of the two Chinook stocks and the degree of genetic mixing that may have occurred is necessary in evaluating management success and developing future management strategies.

Tribe: Skagit River System Cooperative (Swinomish and Sauk-Suiattle tribes)
Name of Project: Evaluation of the need to continue both the fall and summer Chinook salmon coded-wire tag hatchery releases in the Skagit River
Stock and Status: Skagit lower river fall Chinook, ESA threatened
Skagit upper river summer Chinook, ESA threatened
Hatchery: Marblemount (WDFW)
Project Benefit: Critical for recovery monitoring of ESA threatened stocks
Project Description: The Skagit River System Cooperative currently conducts two hatchery indicator stock programs. In the interest of improving hatchery efficiency and per HSRG recommendations, this project will evaluate whether the two programs provide duplicative information on pre-terminal exploitation rates and catch distributions, and if so, which stock is most suitable for indicator stock purposes. Based upon results from this study, if there are significant differences between the two stocks, then both programs will be retained to compile component-specific estimates of trends in marine survival rates, exploitation rates and catch distributions.

Tribe: Skagit River System Cooperative (Swinomish and Sauk-Suiattle tribes)
Name of Project: Identifying relationships and exploring possible mechanisms that influence nearshore survival between hatchery and wild Chinook in the Skagit River
Stock and Status: Skagit lower river fall Chinook, ESA threatened
Skagit upper river summer Chinook, ESA threatened
Project Benefit: Critical for recovery of ESA threatened stocks
Project Description: The goal of this project is to help quantify survival estimates and investigate the degree to which biotic variables are influencing survival of juvenile Chinook salmon in the estuarine delta and marine nearshore environments.

Tribe: Squaxin Island
Name of Project: Acoustic tagging and tracking Squaxin Island coho, Hammersley Inlet wild coho and Percival Cove Chinook
Stock and Status: Wallace River coho, SaSI Healthy
Hatchery: Squaxin Island South Sound net pens / Wallace River (WDFW)
Tumwater Falls (WDFW)
Project Benefit: Collaborative cutting-edge research with significant cost-sharing between agencies and groups to investigate fish interactions
Project Description: Coho salmon stocks in south Puget Sound continue to exhibit exceptionally low survival. There is speculation that the region is acting as a bottleneck on juvenile survival, in part due to carrying capacity effects. The objective of this project is determine fish behavior, duration of residency, rates of outmigration and survival of both hatchery and wild juvenile coho salmon in south Puget Sound. This work is in collaboration with several agencies and groups conducting similar research and involving numerous fish species.

Tribe: Stillaguamish
Name of Project: Stillaguamish Chinook smolt production estimation - characteristics of hatchery and wild contributions
Stock and Status: North Fork Stillaguamish summer Chinook, ESA threatened
South Fork Stillaguamish fall Chinook, ESA threatened

Hatchery: Harvey Creek
Project Benefit: Critical for recovery of ESA threatened stocks
Project Description: This hatchery program is a critical component of the overall recovery strategy for Chinook populations in the Stillaguamish watershed. To direct recovery efforts, it is critical to monitor fish life-history attributes and trends in productivity and survival. More so, it is imperative to operate the hatchery program in a manner that minimizes risks to limited existing genetic resources. This project will provide information necessary to evaluate and adapt hatchery management strategies towards recovery of listed Chinook populations.

Tribe: Tulalip
Name of Project: Assessment of the contributions of Tulalip hatchery Chinook to fisheries escapement using thermal mass-marking of otoliths
Stock and Status: Snoqualmie and Skykomish Chinook, ESA threatened
Hatchery: Bernie Kai-Kai Gobin
Project Benefit: Provides treaty harvest rights while protecting ESA listed populations
Project Description: The Snohomish system is managed for natural production of all species of salmon. The Tulalip Tribe wishes to maintain this management objective while providing treaty harvest opportunity on Chinook salmon during the period of natural stock rebuilding through segregated harvest and hatchery management. This project provides program accountability by demonstrating that 1) harvest targeting hatchery production has minimal impact on local wild stocks, and 2) that the stray rates of hatchery fish to natural spawning areas is within appropriate guidelines.

Type II Projects - construction projects to retrofit, modify, or build facilities; and/or purchase of equipment to improve hatchery practices.

Tribe: Makah
Name of Project: Emergency oxygen backup system for remote sockeye rearing sites
Stock and Status: Lake Ozette sockeye, ESA threatened
Hatchery: Umbrella Creek, remote site incubators
Project Benefit: Minimize risk of catastrophic loss of ESA listed sockeye while in the hatchery
Project Description: The primary goal of the Umbrella Creek sockeye hatchery program is to establish viable naturally spawning populations in the habitats deemed suitable for sockeye in the Lake Ozette watershed. This project will enable the Lake Ozette sockeye reintroduction program to increase the abundance of threatened sockeye salmon by protecting the progeny of natural origin adults from catastrophic loss while residing in the hatchery environment.

Tribe: Nisqually
Name of Project: Predator net system for Kalama Creek Hatchery
Stock and Status: Fall Chinook, ESA threatened
Coho, SASSI healthy
Hatchery: Kalama Creek
Project Benefit: Improve program efficiency in providing treaty harvest opportunity
Project Description: Inventory estimates have indicated losses of up to 12% of total hatchery production prior to release of juvenile fish due to predation. This project will minimize in-hatchery losses due to predation and improve operation efficiency towards providing treaty harvest opportunity.

Tribe: Quinault
Name of Project: Fish loading and transfer pump
Stock and Status: Quinault steelhead
Hatchery: Lake Quinault net pens and Salmon River Fish Culture Facility
Project Benefit: Optimize fish survival and improve program efficiency
Project Description: This project will provide needed equipment for reliable and efficient means to load and handle steelhead smolts for transport from their rearing location in Lake Quinault to point of hatchery releases in the lower mainstem Quinault River. Off-station releases below Quinault Lake are favored to minimize risks to natural populations within the lake due to hatchery -wild fish interactions, including direct predation by hatchery steelhead smolts. Purchased equipment facilitates this management strategy while minimizing injury and stress to both program fish and hatchery personnel.

Tribe: Stillaguamish
Name of Project: Emergency oxygen backup system for circular rearing tanks
Stock and Status: North Fork Stillaguamish summer Chinook, ESA threatened
Stillaguamish Coho, SaSI healthy
Stillaguamish chum, SaSI healthy
Hatchery: Harvey Creek
Project Benefit: Minimize risk of catastrophic loss of ESA listed Chinook while in the hatchery
Project Description: The objective of this project is for design, construction and operation of a backup emergency oxygen delivery system. This hatchery modification will reduce the risk of loss of listed summer Chinook in the event of a reduction or loss of gravity fed water into circular tanks holding both adult broodstock and juveniles.

Tribe: Tulalip
Name of Project: Install bird net support structures in upper Tulalip Creek pond
Stock and Status: Skykomish River coho, SaSI healthy
Hatchery: Bernie Kai-Kai Gobin
Project Benefit: Improve program efficiency by reducing in-hatchery loss of program fish due to predation
Project Description: Hatchery inventory methods have indicated significant in-hatchery loss of program fish, primarily due to bird predation. This project will provide funding for purchase and installation of bird netting at the upper Tulalip Creek rearing and release pond. Expected project benefit is reduced loss of program fish due to bird predation, improved program efficiency and increases in returns and tribal harvest of adult salmon.

D: 2006 Budget

Puget Sound and Coastal Washington Hatchery Reform Project Budget	FY 2006
Hatchery Scientific Review Group	
HSRG Members, Travel, Meeting Costs	$50,000
Tribal Hatchery Reform Demonstration Projects	$200,000
SUBTOTAL	***$250,000***
Long Live the Kings	
21st Century Salmon and Steelhead Management Initiative (Project Management, Facilitation and Communications)	$250,000
TOTAL	**$500,000**

E: Research Priorities for Hatchery Reform

Hatchery Scientific Review Group Technical Discussion Paper
November 2005

Introduction

Application of sound genetic and ecological principles is central to the management of salmon and steelhead hatcheries. Research to promote and evaluate actions stemming from these principles is a necessary priority in support of hatchery reform. Without the refinement and application of these principles, the sustainability of salmon and steelhead populations in Pacific Northwest watersheds will be compromised, and the goals of hatchery reform will not be achieved.

However, determining the correct focus for hatchery reform research is not an easy task. Various groups have undertaken to produce hatchery operational guidelines and research plans in the past (RASP 1992; SRT 1998; APR 1999; ISAB 2003: APRE 2003; NWFSC 2001, 2004). A common approach in these documents is the description of a vast number of operational parameters and research topics that are deemed relevant to understanding the risks and benefits associated with hatchery operations, and using hatcheries to supplement natural populations.

In these research guidance documents, statements about necessary reforms in hatchery technology often imply that research must encompass problems encountered in all life history stages of salmon, and that reform of current practices should be approached by applying several scientific disciplines including genetics, physiology, behavior, nutrition, and microbiology. Direction and guidance is often provided in diverse areas of fish genetics, culture, health and nutrition; hatchery release strategies; ecological interactions (competition, predation); nutrient enhancement; habitat improvements in estuary, migration corridor, and in tributary spawning and rearing habitats; carrying capacity dynamics; etc. However, most of these past plans have provided little or no prioritization among these extensive areas of possible research, to focus on the actions most necessary to achieve hatchery goals.

We are reaching a point in the Pacific Northwest where the number of possible questions is expanding, while the funding available to study all aspects of salmon recovery is diminishing. A number of metrics and evaluators need to be used in determining how to prioritize actions necessary to resolve the key questions pertaining to where supplementation efforts will add to—rather than reduce—the total natural production of salmon and steelhead. As a result of our recent technical discussions, this group suggests that the following criteria should be the primary metrics used to prioritize hatchery research. In the present funding climate, it would seem most appropriate to focus available resources on research topics that fit these four parameters:

1) The *context* for the research and the importance of the question to be resolved.
2) The *degree of uncertainty* associated with the question.
3) The *tractability* of defining an answer to the question.
4) How *generally applicable* the results of the research will be.

In applying these parameters to our discussion of hatchery research priorities, we found two areas that are foundational to hatchery reform: 1) application of genetically integrated and segregated hatchery

operational principles to the management of hatcheries; and 2) application of physiological and ecological principles to produce hatchery fish following a wild fish template, which we hypothesize is the appropriate approach to promote ecological integrity. The genetic goal for hatchery reform is to ensure that hatchery operations do not affect the genetic constitution of natural stocks resident in these watersheds. Instead, hatchery operations should be designed so that the natural environment is the driving force in determining the genetic make-up of natural stocks within these watersheds. Secondly, hatchery operations should be consistent with ecological principles that meet the ecological objectives of the program. It is essential, therefore, that hatchery fish be reared on life history trajectories that mimic natural trajectories and releases sized so that they do not: 1) exceed the carrying capacity of the available riverine, estuarine and marine habitat; 2) displace natural stocks that also depend on that habitat; 3) overwhelm the food base present in that habitat, and 4) diminish the productivity of natural stocks through predation. Areas of focus for these genetic and ecological research topics are described below.

Background and Recommended Research Relating to Stock Genetics

Adaptation to watersheds by the salmonid populations resident in them is critical to the sustainability of these populations. It is also important that the diversity of populations in any given watershed be respected and preserved. Hence, populations should be afforded the opportunity to adapt to the conditions in the watersheds and extended environments they inhabit.

Hatchery practices that inhibit adaptation are inconsistent with long-term goals for both naturally-spawning and hatchery stocks. The frequent past practice of transferring hatchery broodstock among watersheds should be phased out. Instead, hatchery broodstock should be collected from returnees to the watershed where the offspring will be released. Further, all phases of hatchery operations should be consistent with and/or supportive of the continuous process of local adaptation.

Hatchery programs should be operated as either genetically integrated or segregated. Both of these strategies are designed to promote local adaptation and minimize fitness loss of both naturally-spawning and hatchery populations. A critical question is whether segregated and integrated hatchery programs will prove effective, over the long term, in accomplishing this important goal of promoting local adaptation. It is important, therefore, that key natural- and hatchery-origin stocks be monitored over the long-term for evidence of fitness loss or gain attributable to hatchery/natural population interactions. The development of practical methods to quantify fitness loss or gain in salmonid populations should be a high research priority.

In river systems where the infrastructure will permit it, well-controlled experiments to measure rates of adaptation in integrated or segregated populations should be undertaken. These experiments might, for instance, be modeled after genetic monitoring protocols employed in the breeding of other animals. For example, the fitness or breeding values of fish from a founder population that has been allowed to adapt to local conditions for a number of generations might be compared with that of portions of the same population (derived by using cryo-preserved gametes) that have not had the chance to adapt to local conditions for as many generations. Alternatively, fitness changes might rely on identification and monitoring of quantitative trait loci in thoroughly mapped genomes of salmon and steelhead trout populations. Such experiments should be able to identify phenotypic traits that will prove useful as indexes of domestication and adaptation, if the experiments encompass the diversity of ecosystems and the variety of species and life history patterns found in the region.

Background and Recommended Research Relating to Ecological Principles

In planning hatchery programs, the co-managers of the salmonid resource are often confronted with questions relating to the nature (e.g., the type and purpose of the programs, and the strategies used for releasing fish in order to maintain life history patterns of the reared species) and size (in terms of numbers of juvenile fish released) that their hatchery programs should assume. These questions arise because of uncertainties about the amount of suitable habitat available, the size and nature of the natural salmonid populations and other species dependent on the habitat, the capacity of the habitat to provide adequate feed for both natural- and hatchery-origin fish, and behavioral, physiological, and morphological differences between natural and hatchery raised fish.

In conducting research to resolve these questions, the research priority should be the development of qualitative and quantitative models that describe ecological processes and outcomes that could be tested and used as tools for making informed decisions on hatchery release sizes and strategies. These models should be based on general biological principles (i.e., the needs and behavior of salmonids and of the species with which they interact), so that it can take into account site-specific circumstances and be applied to all hatchery programs. In developing these models, monitoring will be needed to provide input data that may be lacking. Monitoring to check the performance of the models will also be required, so that appropriate adjustments can be made to improve the accuracy of the outcomes predicted by the models, with respect to hatchery/wild fish interactions.

Another area of ecological research that is of high importance, but did not seem as tractable, has to do with the role of hatchery fish in freshwater and marine food webs. Salmon are important determinants of aquatic and marine community structure, both as sources of abundant prey and as keystone predators. In some cases, hatchery fish may compensate for natural salmon population decline and help maintain community structure. In other cases, hatchery salmon may disrupt an existing balance. A better understanding of the role that hatchery salmon play in food webs is very important in determining the overall effect of hatchery programs. Further discussion with ecologists and other experts may help us develop tractable approaches to this research in the future.

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F: Rationale for Integrated/Segregated Broodstock Management

The HSRG developed the following text in May 2005, to help clarify what the HSRG meant when it recommended that managers identify each hatchery program as either having an integrated or segregated broodstock management strategy.

- We know from theory and observation that interactions between hatchery- and natural-origin fish will diminish the fitness of naturally-spawning populations, even though this fitness loss is difficult to measure.
- The only way to completely eliminate this fitness loss is to eliminate hatchery programs.
- However, hatcheries can provide harvest benefits.
- Hatcheries have also, in some cases, increased the abundance of populations at risk of extinction.
- Where managers choose to use a hatchery program as part of a strategy to meet harvest and/or conservation goals, there are two ways to manage hatchery broodstocks to address the associated fitness loss.
    1. *Segregated Hatchery Programs*—In these programs, the intent is to manage for two separate gene pools (one adapted to the hatchery, the other to the natural environment) and that hatchery-origin fish do not spawn in the wild.
    2. *Integrated Hatchery Programs*—In these programs, the intent is for the genetic make-up of hatchery-origin fish to be the same as that of the underlying natural population, and that natural selection in the wild drives the fitness of both components of the population. This requires that natural-origin fish be included in the hatchery broodstock and that natural spawning of hatchery-origin fish be minimized.
- In practice, it is in most cases not possible to perfectly achieve either of these strategies.
- It is a reasonable hypothesis that the increased population abundance derived from well-managed integrated or segregated hatchery programs can outweigh the associated fitness losses. Where this hypothesis cannot be supported, a hatchery program may not be appropriate.
- Both integrated and segregated programs can potentially provide fish for conservation purposes, where natural spawning by hatchery-origin fish may be desired.
- When hatchery-origin fish spawn and reproduce successfully in the natural environment, genetic risks of properly-integrated hatchery programs are expected to be less than those from segregated programs for the same level of gene flow from a hatchery program to a natural population.
- Watershed-specific goals and circumstances determine whether a segregated or integrated hatchery program is most appropriate.
- Hatcheries should be used as part of an integrated strategy (alongside harvest management, and habitat protection and restoration) to meet conservation and harvest goals on a sustainable basis.

G: HSRG Memorandum to Hatchery Reform Coordinating Committee Regarding Steelhead Management

MEMORANDUM

May 17, 2005

To: Hatchery Reform Coordinating Committee
From: HSRG Chair Lars Mobrand
Re: HSRG Steelhead Recommendations

The HSRG understands that the co-managers are presently developing a new statewide steelhead management plan, beginning with a white paper. Recent conversations with co-manager personnel and stakeholders indicate that there is some confusion about the HSRG's recommendations relating to Puget Sound and coastal Washington hatchery steelhead programs. The following bullets are presented to help clear up this confusion. We hope they will also be useful in the drafting of the white paper. The HSRG remains interested in providing technical and scientific assistance to the co-managers in the development of the white paper and management plan.

- During the regional review process, the co-managers identified most naturally-spawning steelhead stocks in Puget Sound and coastal Washington as being of high biological significance and low abundance/productivity.
- Most hatchery programs were identified as segregated harvest and released/outplanted non-native stocks of Chambers or Skamania origin. This approach was ubiquitous across the system.
- Also ubiquitous in these programs was inadequate provision for the recapture of unharvested returning hatchery adults.
- Currently, few steelhead programs in Puget Sound are providing significant harvest.
- While it is difficult to monitor escapement and survival of steelhead, it has been shown that significant genetic and ecological[8, 9] interactions occur between hatchery- and natural-origin steelhead. For example, there is a spawning overlap between the

[8] Mackey, G., J.E. McLean, and T.P. Quinn. 2001. Comparisons of run timing, spatial distribution, and length of wild and newly established hatchery populations of steelhead in Forks Creek, Washington. North American Journal of Fisheries Management 21:717-724.
[9] Kostow, K.E., A.R. Marshall, and S.R. Phelps. 2003. Naturally spawning hatchery steelhead contribute to smolt production but experience low reproductive success. Transactions by the American Fisheries Society 132:780-790.

hatchery (Chambers Creek origin), early-timed, winter run stock and the native, late-timed winter run stock at Forks Creek.

- Even small contributions from segregated hatchery populations to small natural populations can lead to a significant loss of fitness.
- Any segregated harvest program conducted under these circumstances will pose a high risk to naturally-spawning steelhead stocks. This creates a conflict between the co-managers' steelhead harvest goals and their conservation goals for natural steelhead populations.
- Because of low abundance and productivity, wild steelhead populations in Puget Sound cannot provide the natural-origin broodstock needed to support integrated harvest programs. Therefore, integrated harvest programs are not currently a viable alternative in most places.
- The steelhead recommendations that resulted from the HSRG's regional reviews were designed to resolve the conflict identified above between the co-managers' harvest and conservation goals. These recommendations include the following elements:
  - Select a balance of large and small streams and habitat types in each region that are not planted with hatchery fish and are instead managed for native stocks. This would reduce the risk of naturally spawning fish interbreeding with hatchery fish, and provide native stocks for future fisheries programs.
  - Fishing for steelhead in these streams would not be incompatible with this approach, but no hatchery-produced steelhead should be introduced.
  - To meet harvest goals, hatchery releases should be in those streams selected for hatchery production. Use locally-adapted broodstock for those streams.
  - Decrease reliance on out-of-basin transfers to backfill shortages in locally adapting hatchery stock. Actions such as harvest restrictions should be implemented to achieve 100% local broodstock.
  - Manage the hatchery stock to maintain its early spawn timing and reduce the likelihood of interaction with naturally-spawning steelhead.
  - Include adult collection capability wherever steelhead are released, to capture as many adults from the returning segregated population as possible. Discontinue releases where adults cannot be collected at return. Investigate feasible sites with adult collection capability, so that returning adults can be collected and removed from natural spawning population.
  - Size the hatchery program in a manner that achieves harvest goals with minimal impact on wild populations.
  - Release hatchery yearling steelhead smolts between April 15 and May 15 at target size of six fish to the pound, and a condition factor of less than 1.0.
  - Implement monitoring and evaluation as a basic component.
  - Investigate the reasons for the recent decline in adult winter steelhead returns, formulate a working hypothesis for the decline and take appropriate actions.

H: Letter from WDFW to Tribal Chairs on Future Hatchery Management

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: 600 Capitol Way N • Olympia, WA 98501-1091 • (360) 902-2200, TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia, WA

August 2, 2005

Chair
Tribe
Address

RE: Future Hatchery Management

Dear Chair,

We share a unique and important government-to-government relationship as co-managers of the salmonid resources in the State of Washington. It is this relationship that carries us through the challenges associated with management of a valuable natural resource that is in part dependent upon an unpredictable environment. We hold in common a commitment to the protection, enhancement and recovery of the salmonid resources and their habitat to ensure conservation of the species and perpetuation of harvest opportunity into the future. In addition, we have a strong interest in ensuring the co-managers drive the decisions relating to operation of the hatchery system into the future.

During the past six years of hatchery reform activities, which have had a principally scientific emphasis to date, a number of tools were developed that afford us as co-managers the opportunity to move our hatchery programs forward through a more informed decision-making process. It also provides the co-managers a means to determine if our hatchery system is meeting our shared goals and objectives. The purpose of this communication is to indicate our interest to work with tribal co-managers on a watershed specific basis to review our stock goals, hatchery program goals, and identify appropriate actions.

Several recent events have prompted our interest in initiating these discussions. The most recent rule by National Oceanic and Atmospheric Administration (NOAA Fisheries) to

include several of our hatchery Chinook populations within the threatened listing status for the Puget Sound Evolutionarily Significant Unit (ESU); the hatchery Environmental Impact Statement (EIS) currently in preparation; the recovery plan development through the Shared Strategy process; and the recommendations coming out of the Hatchery Scientific Review Group. We believe it is important and the timing unparalleled for the co-managers to take the lead on how we expect our hatchery system to operate into the future, not only because of these recent events, but also because if we are to be successful at improving our hatchery system (from facility modifications to natural production management) so that our shared goals and objectives are met, then we need significant financial support at both the state and federal levels. If the co-managers lead the decision-making process and show a commitment through action, then we believe the financial support will come.

WDFW believes the tools developed by the co-managers and the Hatchery Scientific Review Group through the hatchery reform process are value neutral. That is, the tools inform decision-making, but don't make the decision. We liken the tools to a vehicle provided to the co-managers to drive. The details of what the vehicle looks like, how fast it moves, and in what direction will be determined by the co-managers. For example, the application of the integrated/segregated concept of a hatchery program is a policy decision. WDFW believes the concept represents a dial the co-managers turn to set a direction. However, timing and speed will influence progress of the direction.

The WDFW welcomes the co-manager decision to have a regional focus. We propose holding annual progress meetings between co-managers at the regional level to ensure the actions/activities that influence the direction we take meet our shared objectives. Building from the annual management meeting concept, is the recognition that an in-depth review and coordination at a higher policy level would be appropriate periodically as well. The timeline for a higher-level policy discussion may occur at intervals more consistent with evaluating major actions that have been taken or are proposed to be taken in a your region. In addition the more in-depth reviews could be timed based on brood cycles to allow for thorough technical support efforts. Sound technical information and adaptive management should inform decision-making at these policy level meetings.

It's important to reiterate the hatchery reform process has had a principally scientific emphasis to date in order to increase our understanding of the hatchery production programs. Tools were developed to facilitate this knowledge, and these tools have subsequently simplified some of the complexity that surrounds our management. We recognize co-management decisions are complex and multi-faceted, however, the foundation from which we make decisions has become more informed through the use of these tools. The WDFW values the tools developed, because we believe they represent an important means to assist in our decision-making. Therefore, we intend to use the tools and welcome joint discussion, input, review, and decision-making with our co-managers.

The annual co-manager meeting on August 10, 2005 will provide an opportunity to communicate more thoroughly the context for use of the tools, as well as WDFW's interest in meeting with tribal co-managers at the watershed level to determine the direction of respective hatchery programs into the future. We look forward to our meeting and your response.

Sincerely,

Jeff Koenings, Ph.D.
Director

I: Letter from WDFW to Shared Strategy on Recovery Plan Implementation

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February 15, 2006

Mr. Bill Ruckelshaus, Chair
Puget Sound Shared Strategy
1411 - 4th Avenue, Suite 1015
Seattle, WA 98101

Dear Bill,

Congratulations on the completion of the Regional Salmon Recovery Plan for Puget Sound. It is an outstanding document, and provides a valuable roadmap for salmon recovery in Puget Sound. More importantly it represents a consensus of federal, state, local and tribal governments, is based on sound scientific principles and was developed in partnership with local citizens and watershed groups. I am particularly proud of the role that Lead Entities played in the development of the plan.

Implementation of the Puget Sound Salmon Recovery Plan will take coordinated, dedicated efforts of all organizations with a stake in salmon recovery. It will also take leadership and commitment. Broadening the Development Committee to include leadership from each of the watersheds and other organizations that have a clear role in implementation is an excellent step and I look forward to joining you on February 15th to meet the new group. I gladly accept your request for the continued participation of Washington Department of Fish and Wildlife (WDFW) on this new regional leadership group.

I also want to assure you that WDFW is committed to implementing the components of salmon recovery that fall under our jurisdiction. As you know there are many areas where WDFW will play a key role in salmon recovery. I am committed to ensure WDFW continues to address the important building blocks of recovery summarized below.

- All-H Integration: One of our greatest priorities for 2006 is to move ahead quickly on All-H Integration. WDFW will work with tribes, Shared Strategy and watersheds to advance this important aspect of successful salmon recovery. We are starting this process with an All-H Integration work group on February 17th. The group includes members of Puget Sound's Technical Review Team, NOAA, Shared Strategy workgroup, Hatchery Scientific Review Group, Tribes and WDFW. It is my goal, that by the end of the year, we have advanced all-H integration so that each watershed can produce a chapter similar to the "Integration" chapter in the Snohomish River Basin Salmon Conservation plan.

- Harvest Management: The co-manager's Puget Sound Chinook Comprehensive Harvest Management plan serves as the scientific foundation for the development of annual protection strategies that are consistent with the conservation and recovery of naturally spawning fish. The implementation of this plan is having positive results with proven increases in the numbers of listed salmon on the spawning grounds. The plan has long recognized the importance of adaptive management, and that evolution in harvest management will occur in response to improved understanding of the status and productivity of populations. To that end, in conjunction with the upcoming H-Integration process, WDFW intends to review assessment data and ensure that the incidental harvest of Chinook is consistent with estimates of productivity and recovery of the Puget Sound ESU. In short, we must be progressive in where and how to focus harvest opportunities to assure both healthy populations and healthy fisheries.

- Hatchery Reform: The Hatchery Scientific Review provided valuable guidelines and principles to reform hatchery programs. While over 700 of the 1,100 actions are underway, significant work remains to be done. Watershed by watershed, WDFW's hatchery objectives will be reviewed as part of the H-Integration process. This review may lead to changes in hatchery goals and objectives or operations or both. When changes are identified by the co-managers, a hatchery program will be re-evaluated using the scientific tools provided through the hatchery reform process to ensure that the hatchery program is the appropriate size and type for helping to achieve harvest and conservation goals for the watershed.

- Habitat: The Department is supporting implementation of salmon recovery plans through five major efforts:

    - Puget Sound Nearshore Partnership (PSNP): The WDFW is the lead non-federal partner in the Puget Sound Nearshore Ecosystem Restoration Project. The Army Corps of Engineers project is working to complete a science-based feasibility study for a large-scale ecosystem restoration project in Puget Sound. We are also working in conjunction with Puget Sound Action Team to provide support and coordination with the Governor's Puget Sound Initiative and the Puget Sound Partnership. PSNP will continue to provide technical support to priority large-scale restoration activities. In addition, the Department is

working with Lead Entities to identify regional priority salmon recovery projects for funding through the "Estuary and Salmon Recovery" budget request.

- Salmon Recovery Funding Board: The department will continue to actively participate in the Salmon Recovery Funding Board and by supporting the "2496" process. Watershed Stewards will assure that local implementing organizations have access to agency technical tools, data and expertise. In addition, we will expand our efforts to help Lead Entities improve their local prioritization processes. The Department is initiating a project to provide watershed groups with habitat project management tools through development of Habitat Work Schedules. These schedules will help potential project funders find local and regional priority projects. And finally, the Department will continue to support local sponsors, such as Regional Fish Enhancement Groups to identify priority salmon recovery projects to bring forward.

- Habitat Protection: WDFW is beginning implementation of a project to assure that the HPA program and agency land management are being executed in compliance with the federal Endangered Species Act through a variety of potential tools and programs, including HCP's. The Department's Mitigation Optimization project is developing collaborative processes that will bring local, state and federal permitting agencies together to improve the effectiveness of mitigation by linking mitigation decisions to priority watershed restoration and protection needs. Through the Puget Sound Nearshore Ecosystem Restoration Project, WDFW is developing science "white papers" detailing the habitat needs of various species, including juvenile salmon, in the estuaries and shorelines of Puget Sound. The Department will work with local governments to incorporate this science into local land and water management processes. The Department will continue to pursue acquisition and conservations easements for the long-term protection of priority salmon habitat through a variety of local, state, and federal programs, such as the WWRP as outlined in it's recently published "Lands 2020" document. And finally, the Department is committed to improving the effectiveness and efficiency of the HPA permitting process.

- Monitoring and Adaptive Management: WDFW will continue to co-chair and provide staff support to the Governor's Monitoring Forum. WDFW will also continue to participate in the Shared Strategy AAM workgroup and upcoming workshops. Scheduling these workshops to avoid major fish management forums, like North of Falcon, will help us get the appropriate staff at these important workshops. A recent letter from the Association of Washington Cities and the Washington State Association of Counties to Jay Manning, (Director of the Department of Ecology) suggested that Ecology, WDFW,

Shared Strategy, Northwest Indian Fish commission and local jurisdictions get together to discuss common monitoring principles. It is important for all of us to work with them on this request. The Department will continue to expand and improve on its ability to monitor "fish in" and "fish out" for core populations critical to salmon recovery in the Puget Sound basin.

- Finally, all of these activities require adequate funding. The Department will continue to work closely with you, Bill, and to serve as lead for a multi-agency effort to advocate for state and federal funding for the Pacific Coastal Salmon Recovery Fund, the Puget Sound Nearshore Ecosystem Restoration Project, and other projects, programs and activities critical to the implementation of the Puget Sound recovery plan.

Sara LaBorde, WDFW Salmon Recovery Coordinator, will work with Shared Strategy to detail the timeline of these actions, as well as develop a reporting system to ensure that WDFW fulfills these commitments as we move forward.

Bill, thank you for your outstanding leadership and for absolute commitment to a citizen-led, "bottom-up" approach to salmon recovery. I look forward to the opportunity to advance implementation of the Puget Sound Salmon Recovery plan and being an integral part in developing health, sustainable salmon populations in Washington.

Sincerely,
Jeffrey P. Koenings, Ph.D.
Director

J: Letter from WDFW Director to Staff on Hatchery Reform Conference

State of Washington
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December 9, 2005

Name
Division

Dear Name,

On October 28th, the Long Live the Kings and the Mountaineers hosted the "Hatchery Reform: Managing for Success" workshop. This event marked an important step in hatchery reform as it represented the transition from the science-based review and identification of necessary actions to implementation. It also affirmed the commitment by the co-managers to state/tribal implement hatchery reform at a watershed level to achieve our shared goals and objectives.

The Hatchery Scientific Review Group's (HSRG) process that each of you contributed to was a monumental effort. In reviewing over 200 Puget Sound and Coastal Washington programs, you have participated in a process unparallel anywhere in the country. Placing your programs and your efforts under the magnifying glass takes courage as well as an extraordinary amount of time and effort. I am glad you were up to this challenge.

Often times such program reviews fail either under their own weight or from a lack of interest on the "reviewee's" part. I want to thank each of you for your dedication and effort in helping the HSRG make this review process successful. The results of this process – the recommendations and tools like the "All H Analyzer" and "Managing for Success" are excellent contributions to Washington's hatchery and fishery management programs.

An important next step in implementation is making sure there is co-manager agreement on goals and actions. At the annual co-manager meeting in August, there was agreement by the co-managers to collaborate at the watershed level for implementation of hatchery reform, and optimally to integrate our hatchery and harvest actions. WDFW is developing a schedule in cooperation with the Tribes to begin these watershed level specific discussions. Watershed level discussions by the co-managers will focus on stock goals, hatchery program goals, and identification of appropriate actions to achieve our shared goals. Clearly, this watershed specific collaboration will involve significant effort and commitment by all of us, but it is an important step in implementation of hatchery reform.

To make sure we continue making progress, I am asking Heather Bartlett, Paul Seidel, Pat Frazier, and Ron Warren to provide me with a current status and then regular updates on the following:

- Hatchery Reform Actions
  - Actions completed
  - In progress
  - Funded
  - Remaining to be done, their priority and implementation plans

- Goals of hatchery and harvest programs
  - Stock, escapement and program goals
  - Status of joint discussion, input, review, and agreement with our co-managers

- Managing for Success tool
  - Steps to completion for hatchery, harvest and habitat sections
  - Capability to use to report WDFW salmon recovery actions
  - Viewable by staff and citizens

- Communication
  - Method WDFW employees involved in hatchery reform will be kept updated on progress
  - Method this will be included and salmon recovery reporting

It is important that the great work and momentum for hatchery reform continue. Thank you for your continued efforts.

Sincerely,

Jeffrey P. Koenings, Ph.D.
Director

K: Hatchery Reform in Washington State: Principles and Emerging Issues, (Fisheries Magazine, June 2005)

(Available at www.fisheries.org/html/fisheries/F3006/F3006p11-23Seeb.pdf)

Hatchery Reform in Washington State: Principles and Emerging Issues

ABSTRACT

Hatcheries support nearly all major fisheries for Pacific salmon (*Oncorhynchus* spp.) and steelhead (anadromous *O. mykiss*) in the Pacific Northwest. However, hatcheries have been a major source of controversy for over 30 years. The Hatchery Scientific Review Group (HSRG) was tasked by Congress to identify solutions to well-known problems so hatcheries could better meet their goals of supporting sustainable fisheries and assisting with the conservation of natural populations. We reviewed over 100 facilities and 200 programs and identified three principles of hatchery reform: (1) goals for each program must be explicitly stated in terms of desired benefits and purposes; (2) programs must be scientifically defensible; and (3) hatchery programs must respond adaptively to new information. We also identified several emerging issues critical to the success of hatcheries. We concluded that hatcheries must operate in new modes with increased scientific oversight and that they cannot meet their goals without healthy habitats and self-sustaining, naturally-spawning populations.

Introduction

An extensive hatchery system for Pacific salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) has developed over the past 100 years in the Pacific Northwest to mitigate for the effects of overfishing, logging, agriculture, hydropower, urbanization, and associated losses of freshwater salmon habitats (Lichatowich 1999). The Washington Department of Fish and Wildlife (WDFW), several Native American tribes, and the U.S. Fish and Wildlife Service operate more than 100 hatchery facilities within Puget Sound and the Pacific coast of Washington state. These hatcheries release more than 100 million juvenile salmon and steelhead each year and contribute approximately 70% of all salmon harvested in Puget Sound (WDFW 1997). The state of Washington and the treaty tribes of western Washington jointly manage fishery resources in western Washington and are collectively referred to as "co-managers."

A large number of naturally-spawning populations of Pacific salmon and steelhead are currently listed as threatened or endangered under the U.S. Endangered Species Act (www.nwr.noaa.gov/1salmon/salmesa/fractlist.htm). Genetic and ecological interactions with hatchery-origin fish are often cited as one cause of the decline of naturally spawning populations (Waples 1991; Hilborn 1992; Levin et al. 2001). However, the biological effects of hatcheries on natural populations are the subject of much scientific uncertainty and controversy (Busack and Currens 1995; Campton 1995; Brannon et al. 2004). The potential use of hatcheries to help recover natural populations also presents many scientific uncertainties (Hedrick et al. 2000; ISAB 2002; Flagg et al. 2004).

To resolve conflicts between hatcheries and the need for both sustained fisheries and conservation of Pacific salmon and steelhead in Washington state, the U. S. Congress funded the Western Washington Hatchery Reform Project beginning in FY2000 (www.hatcheryreform.org). This project was motivated by recent ESA listings and the important economic and cultural roles of salmon and steelhead fisheries in Puget Sound and coastal Washington. The goal of the project is to determine how hatcheries can best support sustainable fisheries while, at the same time, assist with the conservation and recovery of naturally spawning populations. The project represents a systematic review of all hatchery programs in western Washington, excluding the Columbia River. Congress provided funding to: (a) establish and support an independent panel of scientists to review all hatchery programs and guide the reform process, (b) support a competitive research grants program to address scientific uncertainties associated with hatcheries, (c) support state and tribal efforts to implement hatchery reforms, and (d) facilitate project management by a non-government organization. The independent science panel was established in early 2000 under the name Hatchery Scientific Review Group (HSRG).

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John Barr
Lee Blankenship
Donald E. Campton
Trevor T. P. Evelyn
Tom A. Flagg
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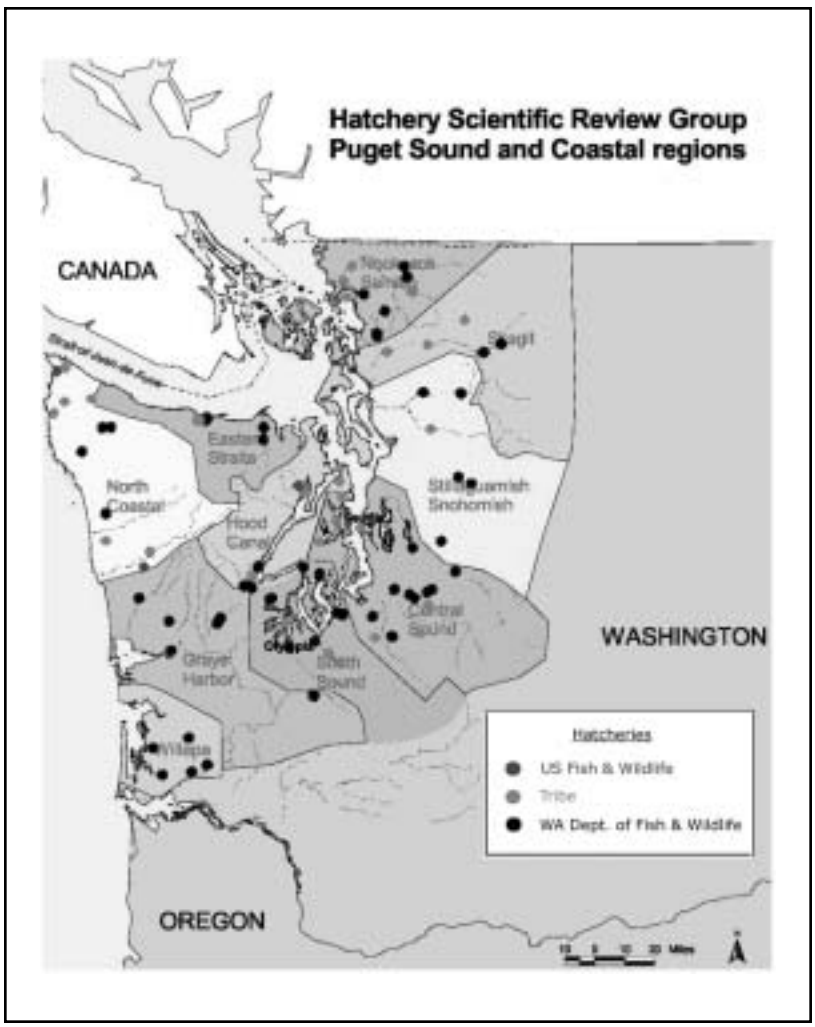
Here, we summarize major conclusions resulting from our reviews of hatchery programs during the past four years. Details of the review process have been described elsewhere (Blankenship and Daniels 2004; Blankenship and Kern 2004) but are briefly summarized below (see also www.hatchery.org).

The Hatchery Review Process

We visited over 100 facilities and evaluated over 200 hatchery programs encompassing 10 major regions in western Washington (Figure 1). Early in the project, we concluded that hatchery programs must be evaluated separately within each region, particularly in the context of the specific ecosystems and watersheds in which they operate; that is, hatcheries must be considered part of the ecosystem in terms of biomass inputs, biomass outputs, predation and competition effects of released fish, effluents, etc. Moreover, each region has unique attributes (e.g., Seattle versus Olympic National Park) that precluded a single, generalized review.

Figure 1. Ten regions in Puget Sound and coastal Washington are shown with locations of state Washington Department of Fish and Wildlife, federal U.S. Fish and Wildlife, and Tribal hatcheries.



We evaluated the benefits and risks of each hatchery program within each region relative to: (1) the purpose and goals of the hatchery program where goals focused primarily on harvest and conservation but included other goals such as research, education and outreach, and social/cultural needs of the western Washington tribes; (2) the biological significance of every hatchery and natural stock within the region relative to other conspecific stocks (see Box 1); (3) the population viability of every hatchery and natural stock (see Box 2); and (4) the current and predicted future status of the habitats on which each stock depends. In addition, salmon biologists and fishery managers, representing state and federal agencies and many tribes, provided us with their short-term (15 years) and long-term (50 years) goals (or predictions) for the biological significance and viability of each stock and the habitats on which those stocks depend. Hence, our evaluations did not simply consider current conditions but predicted, future conditions as well.

Our reviews produced over 1,000 program-specific recommendations and 18 system-wide recommendations for Puget Sound and coastal Washington (Table 1). We are now entering an implementation phase. For example, our reviews led to an $8 million appropriation by the state legislature in FY2005 to initiate implementation of our recommendations. Additional funds will be needed in future years, and ultimately some level of prioritization will be necessary. To assist with prioritizing and implementing our recommendations, we have established three principles of hatchery reform as guidelines.

Three Principles of Hatchery Reform

Principle 1: Every hatchery program must have well-defined goals in terms of desired benefits and purpose.

Well-defined goals provide both targets and measures for success. During our reviews, the goals for many hatchery programs were often not stated clearly or understood by the biologists and managers responsible for the program. For example, the number of juvenile fish released annually was often cited as the goal of a hatchery program. In contrast, we believe the goals for each hatchery program must reflect its intended purpose and desired benefits. The two primary benefits of hatcheries are harvest and conservation, but benefits can include research and education. Wherever possible, goals should be quantified.

Hatcheries should operate as part of an integrated strategy that includes short-term and long-term goals for habitat and harvest. Goals should be related to measures of success, including: (a) the desired number of hatchery-origin fish to be harvested each year so that constraints on the size of the hatchery program can be established, (b) the number of fish returning to a hatchery or spawning naturally in a

Box 1. Criteria for assessing the biological significance of a natural or hatchery population (or stock) within the Puget Sound and coastal regions of Washington state.

Each population or stock was assigned a total score ranging from 5 to 17 according to the following scoring system.

1) **What is the genetic origin of the population or stock?** (possible scores = 1–5)
   a) Native population. Score = 5.
   b) Genetically admixed population between native and introduced populations.
      i) > 50% native genes? Score = 4.
      ii) < 50% native genes? Score = 3.
   c) Reintroduced population: species occurred historically in watershed, was extirpated, but stock transfers re-established species in watershed. Score = 2.
   d) Introduced population: species was historically absent from watershed. Score = 1.
2) **How unique are the biological characters (e.g., life history, physiology, morphology, behavior, disease resistance, etc.) of the stock and to what extent are they considered irreplaceable attributes?** (possible scores = 1–5)
   a) Population has unique, irreplaceable biological attributes that are not shared with other stocks/populations within the same Genetic Diversity. Unit (GDU)[1] or with other GDUs within western Washington. Score = 5.
   b) Population has no unique biological attributes, but shares some unique attributes with other stocks/populations within the GDU not shared with other GDUs. Score = 3.
   c) Population has no unique biological attributes that are not shared with other stocks/populations in other GDUs. Score = 1.
3) **To what extent is the population or stock part of a larger subdivided population structure or metapopulation?** (possible scores = 3–7)
   a) Number of distinct spawning aggregations (e.g. tributaries) within the stock or population under consideration
      i) Number of spawning aggregations < 5. Score =2.
      ii) Number of spawning aggregations > 5. Score = 1.
   b) Total number of populations or stocks within the GDU.
      i) Number of populations/stocks within GDU < 3. Score = 2.
      ii) Number of populations/stocks within GDU > 3. Score =1.
   c) What is the viability of other populations or stocks within the same GDU (see Box 2)?
      i) Mean viability = "high."= Score = 1.
      ii) Mean viability = "medium." Score = 2.
      iii) Mean viability = "low." Score = 3.

Sum of scores and ratings to assess the biological significance of a population or stock:

14-17: Biological significance = High.
9-13: Biological significance = Medium.
5-8: Biological significance = Low.

[1] The Washington Department of Fish and Wildlife defines a GDU as follows: A genetic diversity unit (GDU) is a group of genetically similar stocks that is genetically distinct from other groups. The Stocks typically exhibit similar life histories and occupy ecologically, geographically, and geologically similar habitats. A GDU may consist of a single stock (Busack and Shaklee 1995).

Box 2. Criteria for assessing the viability of a natural or hatchery population (or stock) within the Puget Sound and coastal regions of Washington state.

Each population or stock was assigned a total score ranging from 3 to 14 according to the following scoring system. Note that either question 3 or 4 would be answered for a natural or hatchery population, respectively.

4) **What is the estimated genetic effective size (N_e) of the population or stock?** (possible scores = 1-5)
   a) N_e > 5,000. Score = 5.
   b) 2,500 < N_e < 5,000. Score = 4.
   c) 500 < N_e < 2,500. Score = 3.
   d) 100 < N_e < 500. Score = 2.
   e) N_e < 100. Score = 1.
5) **What is the mean number of recruits per spawner R/S over the preceding 10 years?** (possible scores = 1-5)
   a) R/S > 5. Score = 5.
   b) 3 < R/S < 5. Score = 4.
   c) 2 < R/S < 3. Score = 3.
   d) 1 < R/S < 2. Score = 2.
   e) R/S < 1. Score = 1.
6) **For natural populations only, what proportion of natural spawners is composed of hatchery-origin adults?**
   a) < 1%. Score = 4.
   b) 1–5%. Score = 3.
   c) 5–30%. Score = 2.
   d) >30%. Score = 1.
7) **For hatchery populations only, what proportion of eggs, fry, juveniles, or adults are derived from another hatchery, watershed, or natural-origin fish?**
   a) < 1%. Score = 4.
   b) 1–5%. Score = 3.
   c) 5–30%. Score = 2.
   d) >30%. Score = 1.

Sum of scores and ratings to assess the viability of a population or stock:

11–14: Population viability = High.
7–10: Population viability = Medium.
3–6: Population viability = Low.

watershed (i.e., escapement), (c) the expected results of scientific research, and (d) the educational benefits to be derived from outreach.

Principle 2: Hatchery programs must be scientifically defensible.

Hatchery programs and operations must be consistent with stated goals, and they must be defensible scientifically. Hatchery programs are often not consistent with goals or the best available scientific information (e.g., Campton 2004). Once the goals for a program are established, the scientific rationale for the design and operation of the program must be explicitly stated and understood by all personnel. These requirements may necessitate a written, comprehensive management plan for every hatchery program. Scientific oversight and peer review should be integral components of every hatchery program.

Every hatchery program provides research opportunities. Indeed, one of the recognized benefits of salmon hatcheries is the opportunity to advance scientific knowledge. For example, every hatchery program creates research opportunities related to the effects of culture on the biology of the propagated species and the effects of the released species on aquatic ecosystems. Partnerships between hatchery staffs and scientists should be encouraged. These research opportunities should be exploited wherever possible.

Every hatchery program needs to have operational guidelines and standard operating procedures (e.g., selection of adults for broodstock, spawning protocols, feeding protocols, etc.) that are scientifically defensible. These guidelines should include decision-making pathways for dealing with unexpected contingencies.

Principle 3: Hatchery programs must respond adaptively to new information.

Measuring Success and Accountability. Scientific monitoring and evaluation (M&E) of hatchery programs needs to be expanded to determine whether hatcheries are achieving their goals. If conservation is the goal, a major effort should be made to obtain a census of marked hatchery fish spawning with their natural counterparts and to estimate the impact of hatchery fish on the fitness of the natural component. If harvest is a goal, the focus should be on the contribution of hatchery-origin fish to fisheries and the potential impacts of hatchery fish on natural spawners. M&E should assess smolt-to-adult survival, return rates of adults, contribution of adults to harvest and natural spawning, the proportion of naturally-spawning fish composed of hatchery-origin adults, stray rates of adults to non-target watersheds, and life history traits related to fitness. Where possible, M&E should include assessments of genetic and ecological interactions (e.g., interbreeding, competition, predation, and reproductive success) between hatchery- and natural-origin fish. Biologists should also monitor life history, morphological, and other traits related to fitness because of the potential domestication effects of hatcheries. Most importantly, centralized and standardized databases need to be developed for collating, storing, and retrieving data. Results need to be evaluated annually to allow programmatic adjustments.

In most cases, the existing hatchery staff may not necessarily have the expertise to also serve as M&E biologists. Hence, a hatchery evaluation team, including perhaps the manager of each facility, may need to be developed for a particular region. Indeed, biologists responsible for collecting and analyzing

Table 1. Principles for hatchery management and system-wide recommendations developed by the Hatchery Scientific Review Group.

1) **Well-defined goals:**
   - Set goals for all stocks and manage hatchery programs on a regional scale
   - Measure success in terms of contribution to harvest, conservation, and other goals
   - Have clear goals for educational programs

2) **Scientific Defensibility:**
   - Operate hatchery programs within the context of their ecosystems
   - Operate hatchery programs as either genetically integrated or segregated relative to naturally-spawning populations
   - Size hatchery programs consistent with stock goals
   - Consider both freshwater and marine carrying capacity in sizing hatchery programs
   - Ensure productive habitat for hatchery programs
   - Emphasize quality, not quantity, in fish releases
   - Use in-basin rearing and locally-adapted broodstocks
   - Select adults randomly throughout the natural period of adult return
   - Use genetically-benign spawning protocols that maximize effective population size and minimize potential artificial or domestication selection under hatchery conditions.
   - Reduce risks associated with outplanting and net pen releases
   - Develop a system of wild steelhead management zones (a special case)
   - Use hatchery salmon carcasses for nutrification of freshwater ecosystems, while reducing associated fish health risks

3) **Informed Decision Making:**
   - Adaptively manage hatchery programs
   - Incorporate flexibility into hatchery design and operation
   - Evaluate hatchery programs regularly to ensure accountability for success

data, including the generation of annual reports and publications, should be considered an integral component of every hatchery, equal in importance to fish health specialists who monitor pathogenic loads and help reduce the risk of disease outbreaks. However, it should be recognized that the statistical power to detect undesirable effects, particularly on fitness-related traits, may be very low, so the absence of a detectable effect should not be used as a justification to violate a scientifically-defensible guideline (e.g., as described by Campton 2004). In this context, policies and operational guidelines need to be established and followed accordingly. Moreover, those policies and guidelines need to be subject to change in response to new information generated from M&E activities.

Adaptive Management. Hatcheries need to be flexible and managed adaptively. Many scientific uncertainties are associated with salmon hatcheries. Hatchery programs and facilities must respond to new goals, new scientific information, and changes in the status of natural stocks and habitat. A structured adaptive management program is necessary for the success of hatcheries. Institutional resistance to programmatic flexibility and change needs to be overcome.

We should also note that the three basic principles of hatchery reform are equally applicable to all hatchery programs regardless of whether the purpose of the program is to provide fish for harvest, to assist with conservation of natural populations and their indigenous genetic resources (e.g. Flagg et al. 2004), or both (e.g., Olson et al. 2004). The details of an individual program will be case-specific for both harvest-oriented and conservation-oriented programs, but the underlying principles and operational guidelines will be similar. However, conservation hatchery programs designed to prevent extirpation of an imperiled population do present some special challenges, and those challenges and special considerations are described in detail elsewhere (Flagg et al. 2004).

Emerging Issues and Concepts

A number of key issues emerged during our review process. Here, we summarize our conclusions and recommendations for some of those key issues. More detailed analyses and descriptions are available at www.hatcheryreform.org.

Genetic Integration vs. Segregation of Hatchery Broodstocks Relative to Natural Populations.

Adult spawners for broodstock are usually obtained from returnees back to a hatchery or from trapped adults diverted by a barrier weir. Whether such adults are of natural- or hatchery-origin was usually unknown. In short, hatcheries have historically had no formal genetic management plan or strategy for their component broodstocks.

Consequently, the first step towards "hatchery reform" is to develop a detailed genetic management plan or strategy for every hatchery broodstock. Managers have two options: (1) manage a hatchery broodstock as a reproductively distinct population that is genetically segregated from naturally spawning populations, or (2) manage a hatchery broodstock as a genetically integrated component of an existing natural population (Figures 2,3). Each of these broodstock strategies leads directly to a different set of operational guidelines. Genetically segregated broodstocks are generally derived strictly from hatchery-origin adults returning to the hatchery each year. Conversely, genetically integrated broodstocks systematically include a prescribed proportion of natural-origin fish in the broodstock each year to maintain genetic integration with a natural population. One goal of integrated hatchery programs is to minimize the genetic effects of domestication by allowing selection pressures in the natural environment to drive the genetic constitution of hatchery-origin fish and the mean fitness of the population as a whole. In contrast, segregated hatchery programs create a genetically distinct, hatchery-adapted population.

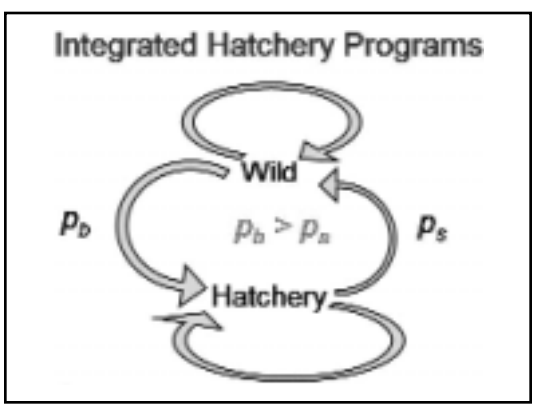


Figure 2. Schematic diagram of a genetically integrated hatchery program. The integrated approach treats hatchery and natural-origin fish as two components of a common gene pool, where p_b is the proportion of the hatchery broodstock composed of natural-origin fish, and p_s is the proportion of natural spawners in the watershed composed of hatchery-origin fish. Natural spawning by hatchery-origin fish from a properly integrated program ($p_b > p_s$) presents a lower genetic risk than segregated programs ($p_b = 0$) for the same value of p_s. For many hatcheries and geographic locations, the value of p_s cannot be directly controlled, and the mean value of p_s may thus be a deciding factor for determining whether a segregated or integrated program is most appropriate for a particular facility and geographic location where fish are released. Regardless of program type, p_s should be minimized.

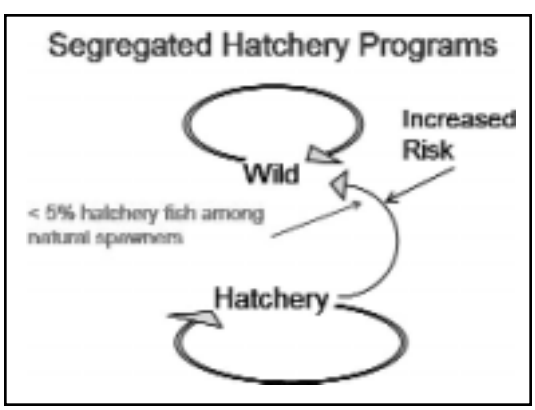


Figure 3. Schematic diagram of a genetically segregated program. The segregated approach treats hatchery fish as a distinct population or isolated gene pool. Natural spawning by hatchery-origin fish ($p_s > 0$) from a genetically-segregated program can pose a high risk to natural populations if those hatchery-origin fish are able to reproduce successfully.

The goals of genetic integration can be achieved only if the rate of gene flow from the natural environment to the hatchery environment exceeds the reverse rate of gene flow (e.g., Ford 2002). These gene flow parameters are difficult to estimate directly but can be approximated by the proportion of the hatchery broodstock composed of natural-origin fish (p_b) and by the proportion of natural spawners in the watershed composed of hatchery-origin fish (p_s), with the goal $p_b > p_s$ (Figure 2). The mean fitness (f) of an integrated population in the natural environment, relative to a natural population by itself, will largely be determined by the relationship $f = p_b / (p_b + p_s)$ (Lynch and O'Hely 2001; Ford 2002). The parameter f also equals the proportion of time that genes are transmitted from parents to offspring in the natural environment versus the hatchery environment. At a minimum, we recommend $p_b > 0.1$ for integrated programs to help overcome the effects of genetic drift and unknown amounts of domestication selection in the hatchery environment, even when p_s may be near zero (see Ford 2002). In most cases, p_s will not equal zero because of logistic difficulties controlling the natural spawning of hatchery-origin adults. Consequently, one major motivation for an integrated hatchery program is to substantially reduce the genetic risks of hatchery-fish spawning naturally relative to genetic and ecological risks imposed by hatchery-origin fish from a genetically segregated broodstock. We are currently developing mathematical models to address these concepts further.

Hoodsport Hatchery is located within the Hood Canal region of western Washington. Hoodsport Hatchery annually releases 15 million chum salmon fry. The HSRG recommended reducing the program size to avoid large surpluses of unharvestable fish and to minimize potential risks to natural-origin chum salmon juveniles.

Issaquah Hatchery is located in the Lake Washington drainage of western Washington. The hatchery includes extensive educational programs and public access facilities serving the greater Seattle area.

An integrated hatchery program requires, as a long-term goal, a self-sustaining, naturally-spawning population capable of providing adult fish for broodstock each year. Integration thus requires suitable natural habitat capable of sustaining a natural population. Under this strategy, an integrated hatchery does not replace habitat but adds to existing habitat. An implicit goal of an integrated program is to demographically increase the abundance of a natural population while minimizing the genetic effects of artificial propagation. This demographic increase in abundance could simply be for the purpose of supporting harvest while minimizing genetic risks to natural populations or it could reflect a conservation component of the program itself. Thus, integrated programs can have both harvest and conservation goals (e.g., Olson et al. 2004). However, the size of an integrated hatchery program will necessarily be limited by the habitat available to the natural populations with which it is integrated and by the ability of the hatchery program to restrain natural spawning by hatchery-origin adults.

Segregated hatchery populations will diverge genetically from naturally spawning populations over time because of founder effects, genetic drift, and domestication selection in the hatchery environment. Such changes may be intentional (e.g., via selective breeding) to maximize benefits or the operational efficiency of a hatchery program. However, natural spawning by hatchery-origin fish can have a significant genetic influence on natural populations after several generations when p_s approaches 10% (Ford 2002); consequently, we recommend that hatchery-origin spawners from genetically segregated programs represent < 5% of the natural spawners as an upper-limit guideline (Figure 3). Segregated programs are, thus, most appropriate when harvest is the principal purpose of the program and the probability of hatchery-origin adults spawning naturally and reproducing successfully is very low. On the other hand, hatchery-origin fish from a segregated broodstock could support a conservation goal if fish were "outplanted" into areas where a natural population was extirpated. Hence, both integrated and segregated programs can have both harvest and conservation goals depending on the specific situation.

The development and management of genetically integrated or segregated hatchery broodstocks clearly requires a mechanism to distinguish natural and hatchery-origin adult fish via intrinsic and extrinsic marks and tags (e.g., otolith marks, DNA profiles, coded-wire tags, fin marks, etc.). Such a distinction is required during the selection of adults for broodstock and for monitoring the potential genetic contribution of hatchery-origin fish to natural reproduction. Moreover, this distinction is required also for monitoring harvest impacts on both hatchery-propagated and natural populations. Hatchery reform cannot occur independently of "harvest reform" and habitat improvements. All three components must be managed together to achieve long-term and sustainable conservation and harvest goals for Pacific salmon and steelhead resources.

During our HSRG reviews, the co-managers identified the intent of every hatchery program as either integrated or segregated. The breakdown between integrated and segregated programs identified by the co-managers was 54% versus 46% respectively. They also needed to identify the purpose of the program as either harvest, conservation, research, and/or education. We then provided recommendations for achieving those collective goals. In some cases, we recommended that they change the intent of their program from an integrated program to a segregated program, or vice versa, if their intended strategy was inconsistent with the capability of the habitat, stray rates from the hatchery, or other factors beyond their

immediate control. Simply establishing these hatchery broodstock strategies for each hatchery program was a major step towards satisfying Principle 2 of hatchery reform.

Marine Carrying Capacity

Trends in the carrying capacity of the marine environments must be considered for determining the number of fish released from a hatchery. Until recently, marine ecosystems were believed to be stable, internally regulated, and largely deterministic. The current view is that these systems are dynamic with much environmental stochasticity and ecological uncertainty (Mahnken et al. 1998; Francis 2002).

Based on earlier assumptions that marine carrying capacity was unlimited or had not yet been reached, the goal of increasing fisheries was pursued by building more hatcheries and releasing more fish. As a result, the number of juvenile salmon released from Pacific Northwest hatcheries increased substantially after the early 1960s (Mahnken et al. 1998). Equally large increases occurred in Japan and Alaska (NPAFC 2003; Smoker and Heard in press). However, during the same period, the mean length and weight of returning adults decreased and their mean age at maturity increased for most stocks of Pacific salmon (Kaeriyama and Urawa 1992; Rogers and Ruggerone 1993; Bigler et al. 1996). In general, between the mid 1970s and the late 1990s, the marine survival rates of the great majority of Northeast Pacific salmon stocks north of 54°40′ N increased rapidly while southern hatchery stocks exhibited decreasing marine survival (Hilborn and Eggers 2000; Wertheimer et al. 2001; Wertheimer et al. 2004). Decreasing smolt-to-adult survivals of southern North American hatchery stocks during the late 1970s and late 1980s only motivated co-managers to release more hatchery fish to compensate for reduced fisheries catch.

The ocean ecosystem in which Pacific salmon reside is dynamic, changing seasonally and on longer decadal scales. El Niños and the Pacific Decadal Oscillation (PDO) are examples of short- and long-term oscillations in the ocean environment that can affect Pacific salmon survival and abundance. At present, it will be difficult to manage Pacific salmon hatcheries on time scales as short as the El Niño owing to the unpredictability of onset of the event. However, for decadal time scales on the order of the PDO, it may be possible to modulate hatchery production to accommodate gradually changing ocean productivity. Agencies need to engage in dialogue to address managing hatchery production during these longer, more predictable periods of natural oscillations in Pacific ecosystem productivity.

Smolt Quality

The quality of hatchery-origin smolts has often been described in terms of mean size, numbers, or condition index of fish produced, and whether they met a pre-determined time window for smoltification and release. Fish size at release was used almost invariably as a surrogate for fish quality. Although the scientific literature provides physiological, morphological, and behavioral definitions of a quality smolt, those definitions were rarely used by hatchery personnel. Moreover, the biological relationship between those measures and parameters associated with returning adults (e.g., age class structure, mean size at maturity, etc.) was rarely investigated. With the advent of coded-wire tags, most studies to identify relationships between smolt quality and adult returns were aimed at manipulating the mean size and release time of juveniles with the goal of maximizing smolt-to-adult survivals. In addition, some researchers investigated the role of nutrition (proximate composition, constituent quality, etc.) for maximizing adult returns.

We now recognize that smolt quality includes morphological, physiological, and behavioral characters that embody the rate and completeness of the parr-smolt transformation. A quality smolt is defined as a metamorphosed, anadromous salmonid that exhibits rapid downstream migration, increased hypo-osmoregulatory capability, sustained growth in the ocean, and high survival to adulthood. Smolt quality is not an absolute concept; it has to be evaluated in the context of program goals. If the primary goal is conservation, then an analysis of smolt quality needs to consider how hatchery smolts compare in life history traits to wild fish. Mimicking the growth pattern, size, and out-migration timing of natural fish has been shown to have the potential to produce a higher quality hatchery smolt with greater smolt-to-adult survivals (Larsen et al. 2001; Maynard et al. 2004).

Research, funded by the HSRG, is being conducted at the Lilliwaup Hatchery to evaluate release strategies for steelhead recovery in Hood Canal in western Washington.

As an operational guideline, we recommend expanding the definition of smolt quality to include additional physiological, morphological, and behavioral measurements taken throughout the culture cycle. Examples include gill Na–K ATPase enzyme activity, blood concentrations of thyroid hormones, growth hormone, insulin, insulin-like growth factor, and body lipid levels. Such an approach will require increased physiological monitoring of juveniles prior to release. One simple measure of physiological smolt development is the rate of change in growth rate

immediately preceding and during the parr-smolt transformation (Beckman et al. 1996). Increasing the accuracy of smolt quality indices may allow the number of smolts released to be reduced while achieving the same number of returning adults.

Outplanting and Remote Releases.

The vast majority of salmon hatcheries in the Pacific Northwest operate largely as adult spawning and juvenile rearing facilities. The standard method of propagation is to release smolts into stream areas where returning adults can be recaptured for broodstock. In practice, though, smolts are often released from sites where adult collection facilities do not exist, primarily to support fisheries in off-site areas. In many situations, smolts are transported by hatchery truck into other watersheds, sometimes over relatively large distances (e.g., >100 km) prior to release. Adults generally return to areas where they were released as smolts, not where they were reared.

Releasing smolts into streams geographically removed from a hatchery or adult collection facility, primarily for the purpose of supporting fisheries in specific streams or areas, is commonly called "outplanting." Steelhead programs in Washington State outplant smolts into a large number of small streams to support recreational fisheries where no hatchery facilities exist. Salmon smolts are also released remotely from floating net pens in marine areas where a targeted fishery on returning adults is desired. Outplanting, as defined above, should not be confused with supplementation which, in the Pacific Northwest, refers specifically to the deliberate release of fish in areas where managers explicitly desire returning adult fish to spawn and naturally reproduce as a mechanism to increase the abundance of natural-origin adults one generation later. In general, natural spawning of hatchery-origin fish is not a goal of "outplanting."

A common feature of outplanting and net pen programs is the absence of facilities to trap returning adults that escape target fisheries. Non-harvested adults can then spawn in streams far-removed from the source hatchery or geographic location where their parents were trapped for broodstock (e.g., Pascual and Quinn 1994). Moreover, stray rates of fish released off-station are generally greater than those of fish released directly from hatcheries (Quinn 1993). Indeed, tagging and genetic studies have shown that outplanting and net pen programs promote stray rates that far exceed natural levels (Candy and Beacham 2000; Mackey et al. 2001). Many studies have further indicated a genetic component to homing such that non-native fish and their progeny stray at higher rates than identically-reared native fish (Bams 1976; McIsaac and Quinn 1988; Pascual et al. 1995; but see Smoker and Thrower 1995; Gilk et al. 2004). We concluded that outplanting and net pen releases pose significant, and potentially unacceptable, genetic risks to natural populations and recommended several measures to reduce risks associated with outplanting (HSRG 2004). These recommendations include reductions in the number of fish released from saltwater net pens, removal of all or nearly all hatchery returnees in concentrated fisheries, the construction of juvenile acclimation and adult recapture facilities, and the potential establishment of wild salmon and steelhead management zones.

Predation on Natural-Origin Salmonids.

Concern is often expressed about the potential for hatchery-reared salmon and steelhead to prey on natural-origin juvenile Pacific salmonids, particularly regarding the impact of predation on threatened or endangered populations (Lichatowich 1999; Levin et al. 2001; see also Sholes and Hallock 1979; Beauchamp 1990; Hawkins and Tipping 1999 for the potential of predation). Predation on natural-origin fish is most likely in the freshwater environment, where potential salmonid predators are concentrated and exposed to large numbers of prey in a relatively small area. There is little evidence that natural-origin salmonids are preyed on by hatchery-reared salmonids in estuarine, nearshore, or offshore marine environments. However, estimation of the overall predation risk to natural-origin salmonids from hatchery-reared salmonids is complicated because such risks depend on the pisciverous nature of an individual stock and on a number of stochastic factors including migration rates, stream conditions, and spatial and temporal overlap between hatchery- and natural- origin fish.

There is evidence that salmonids are able to prey on fish up to approximately 50% of their body length (e.g., Damsgard 1995; Pearsons and Fritts 1999; Finstad et al. 2001). However, Keeley and Grant (2001) estimated that the mean prey size for 100–200 mm salmonids feeding on fish in streams is normally 13–15% of predator body size. The relative sizes of downstream-migrating smolts or fry of different species of salmonids in Washington suggest that several possible predator/prey combinations are likely to occur (Figure 4). Natural-origin pink (*O. gorbuscha*) and chum salmon (*O. keta*) and ocean-type (i.e., that smolt as subyearling) Chinook salmon (*O. tshawytscha*) are most likely to be preyed upon by hatchery-reared salmonids in Washington. Hatchery-reared chum, pink, sockeye (*O. nerka*), and ocean-type Chinook salmon are unlikely to prey on wild salmonids due to their relatively small size at release and/or their non-piscivorous feeding habits. Yearling coho (*O. kisutch*), stream-type (i.e., that smolt as yearlings) Chinook salmon, and steelhead smolts have the greatest likelihood of preying on wild salmonid fry due to their large relative size at release. Smolts that remain (residualize) in rivers for months or years after release may represent an important predation risk to wild salmon populations.

Hatchery managers have numerous production tools that can minimize predation risk of migratory hatchery fish with their natural-origin counterparts. For example, design of rearing and release protocols allow the hatchery manager the option of producing fully-developed, highly-migratory smolts that rapidly migrate to the marine environment. The relative vulnerability of wild juvenile salmonids to predation in freshwater may depend on the release location of hatchery fish. Hatchery managers will need to conduct case-by-case determinations of predation risk that may require specific research on spatial and temporal overlap of hatchery-reared and wild fish, estimation of specific predation rates, and modeling to determine the potential population effects on wild salmonid populations.

Stream Nutrification and Fish Health

Returning adult salmon transfer marine nutrients into terrestrial and freshwater ecosystems, contributing significantly to primary production, riparian vegetation, and even old-growth forests (Kline et al. 1990; Bilby et al. 1996). Those nutrients also contribute significantly to the food sources of juvenile salmonids. For example, in one study, up to 60% of the fixed nitrogen in benthic insects was derived from salmon carcasses (Johnston et al. 1997). Those latter investigators also found that juvenile salmon have higher growth rates in streams where adult salmon spawn than in streams without spawning adults. Hatchery-origin salmon carcasses also increased the density of age 0+ coho salmon and age 0+ and 1+ steelhead in small streams in southwestern Washington (Bilby et al. 1998). Distributing spawned out salmon carcasses from hatcheries into watersheds can thus confer a positive ecological benefit to stream nutrification and naturally spawning populations.

However, spawned-out salmon carcasses from hatcheries can pose a fish health risk to natural populations if the carcasses are not properly treated or inspected prior to distribution. Pathogenic organisms present in salmon carcasses can be transmitted to other salmonids either through release of those organisms into water or through their direct consumption. It is well established, for example, that bacterial and viral pathogens of salmonids can be transmitted via water or the oral route, and, in the laboratory, challenges by both routes have been used in various studies for establishing infections with a number of microbial fish pathogens (see, for example, Evelyn 1996 for various bacterial fish diseases and Helmick et al. 1995 for infectious hematopoietic necrosis virus infections). In addition, the shedding of bacteria and viruses responsible for these diseases from infected fish has been well documented (see, for example, Mulcahy et al. 1983 and Zhang and Congleton 1994 for infectious hematopoietic necrosis; McKibben and Pascho 1999 for bacterial kidney disease; Rose et al. 1989 and Perez et al. 1996 for furunculosis; Madetoja et al. 2002 for bacterial coldwater disease). Such horizontal transmission is enhanced in hatcheries. Adult salmon trapped for hatchery broodstock are typically held in crowded ponds or raceways for days or weeks prior to spawning, potentially exacerbating the prevalence and transmission of pathogenic organisms among hatchery-spawned adults. In many of those fish, the infectious load can be expected to approach the loads found in fish dying of various infections. In such fish, the infectious load of bacterial cells or virus particles can reach titers of 10^3 to 10^9 infectious units per gram of tissue, depending on the tissue (see Evelyn 2001). Consequently, every effort should be made to ensure that hatchery-origin carcasses intended for use in stream nutrification projects undergo some form of post-spawning treatment to minimize the disease risks to natural populations (e.g., deep freezing of the carcasses at –20° C, which kills certain fish pathogens or preferably processing of the carcasses into pellets, such as those studied by Wipfli et al. (2004) would almost certainly be pathogen-free). Failing that, pathogen-free certification of the carcasses prior to distribution for stream nutrification projects would be strongly recommended.

Conclusions

Salmon hatcheries have been a major source of controversy in the Pacific Northwest for over 30 years (Lichatowich 1999; Brannon et al. 2004). Several panels of scientists have been assembled in the past to identify and evaluate the biological risks posed by hatcheries on anadromous salmonid resources (e.g., IHOT 1994; NRC 1996; Brannon et

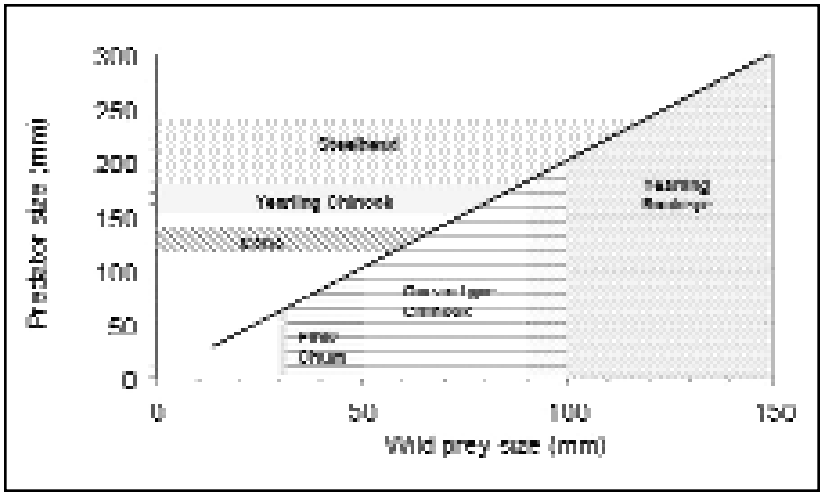


Figure 4. Relative sizes of hatchery-reared salmonid predators (at release) and their potential migratory salmonid prey in Washington, assuming that predators may consume fish up to 50% of their body size.

al. 1999; ISAB 2002). Virtually all of those previous assessments have focused on the problems and risks posed by hatcheries. However, few of those assessments were tasked with developing scientifically-defensible solutions to the problems they identified.

The HSRG was mandated by Congress to identify potential solutions to widely-recognized problems to ensure that hatcheries contribute to supporting sustainable fisheries while supporting conservation, restoration, and recovery of natural populations. A significant portion of the Puget Sound area is urbanized, and hatcheries provide an essential component to the commercial, tribal, and recreational fisheries of the region. In addition, major habitat restoration programs are in place, or are planned, thus providing significantly improved opportunities for naturally spawning populations in the future.

We focused our review efforts during the past four years on identifying scientific uncertainties and proposing solutions based on the best available science. The need to develop broodstock genetic management plans for every hatchery program with the goal of managing each broodstock as either a genetically-segregated "hatchery population" or as a genetically-integrated component of an existing "natural population" became a fundamental foundation for our recommendations. Both strategies require the ability to distinguish hatchery- and natural-origin adults, both in the hatchery when adults are spawned for broodstock and on the natural spawning grounds, to assess the genetic risks and gene flow rates of hatchery-origin fish to natural populations. Commensurate with these reforms is the need for increased monitoring and evaluation, scientific oversight, and accountability of hatchery operations. In many cases, these reforms will require additional funding by the management agencies, but this investment should be considered a cost of operating hatcheries to ensure benefits are achieved and risks controlled. Ultimately, the success or failure of a hatchery program may be measured by the relative benefits and risks it confers. Although it is beyond the scope of this article to deal with benefit-risk analyses of hatchery operations, readers should consult other essays on this topic as a complement to our presentation here (Busack and Currens 1995; Currens and Busack 2004; Waples and Drake 2004).

Unless all habitat has been irrevocably lost to a dam or other impassible barrier, hatcheries should not be regarded as surrogates or substitutes for lost habitat. Hatcheries need to operate in scientifically-defensible modes with well-defined goals and substantially increased data collection and evaluation. Hatcheries also need to be flexible and adaptable; that is, they need to operate and be evaluated in the context of both the ecosystem (watersheds) in which the hatcheries occur and other ecosystems and ecological processes on which hatchery-origin fish depend.

Scientific uncertainties associated with hatchery operations are numerous. The science to manage these risks is still inadequate, and some of the risks are still poorly understood (e.g., Currens and Busack 2004). However, one point is clear. Maintaining healthy habitat is critical not only for viable, self-sustaining natural populations, but also to adequately control risks of hatchery programs and realize the benefits of hatcheries to recover populations and sustain healthy harvests in increasingly populated environments. Moreover, the principles and emerging issues we describe here are not only applicable to hatcheries for Pacific salmon and steelhead in western Washington state, they also have direct application to other regions of the Pacific Northwest and to artificial propagation programs for other species worldwide.

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