APRE

Artificial Production Review and Evaluation

DRAFT
Basin-Level Report

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Executive Summary

This report summarizes the results and conclusions of the Artificial Production Review and Evaluation (APRE) conducted by the Northwest Power and Conservation Council (Council) in response to a request from Congress to review all federally funded hatchery programs in the Columbia River Basin. The goal of the review is to develop coordinated policies for the use of artificial production in the Basin. The Council subsequently expanded the review to include hatcheries supported by non-federal funds as well.

Interest in artificial production stems from scientific and policy concerns about the success of artificial production programs and how they affect other aspects of fisheries management. Despite the fact that artificial production has occurred in the Pacific Northwest for over 100 years, a comprehensive look at the success or failure of the programs has not been undertaken. The APRE partially addresses this deficiency by conducting an in-depth evaluation of 227 individual salmonid hatchery programs within the U.S. portion of the Columbia River Basin. The results of the review are expected to provide the basis for regional fisheries planning efforts by all parties involved in Pacific Northwest hatcheries. Discussions of the future of hatcheries and identification of the benefits and risks of hatchery practices should also occur as a result of the review and evaluation.

Hatcheries in the Columbia River Basin were established originally to maintain commercially harvestable numbers of salmon. Within the past few decades, however, the focus has changed to supplementation of wild populations. The passage of the Endangered Species Act of 1973 and changing public perceptions about the importance and use of salmon have had great influences on the purpose of hatcheries.

For each hatchery program in the Basin, APRE identified the program's purpose, the extent to which the program is meeting that purpose (benefit), and considered the potential for negative impacts on other purposes and priorities (risk). The review process was based on the hatchery review developed by the Hatchery Scientific Review Group (HSRG) in Washington State. Questionnaires which collected information on hatchery goals and operations from hatchery managers and operators were developed and the responses entered into a database (www.apre.info). The responses were evaluated against the APRE working hypothesis which states that: a) to be successful, a hatchery program must be internally consistent with its own stated purpose and externally consistent with the goals and priorities of the environment, including other potentially affected fish populations; and b) almost any human intervention to manipulate the environment poses some level of risk to the existing environment and species. A hatchery program was judged to be successful if it met the following 4 major conditions:

1. It must produce a healthy and viable hatchery population.
2. It must make a sustainable contribution of adult returns to conservation and/or harvest.
3. Its potential effects on wild and native populations and the environment must be understood.
4. It must collect, record, evaluate, and disseminate information pertaining to the first three conditions so that decision-makers may be informed about the benefits and risks of the program relative to other means of achieving similar conservation and harvest goals.

The information database is intended to form the foundation for continuing consideration of artificial production in the Basin. The individual program reports contain a summary of facility information including operator, funding sources, and overall performance. The database is designed to be updated as new information becomes available and hatchery reforms are enacted.

The results of the APRE are examined in 6 major categories: fish stocks, hatchery operations, distribution of hatchery releases, hatchery goals and purposes, funding, and monitoring and evaluation.

- Fish Stocks*: The study identified 505 fish stocks of which 245 were natural stocks, 115 were integrated*[1] *stocks, and 145 were segregated*[2] *hatchery stocks. The majority of stocks were found in the Lower Columbia province.*
- *Hatchery Operation*: The majority of hatchery programs in the lower Columbia River are segregated; most in the upper river are integrated programs.
- *Hatchery Practices*: Many segregated hatchery programs contribute significantly to wild spawning populations, despite the intention to separate hatchery and wild fish. The amount of mixing was unknown in a third of segregated programs. In addition, 41 percent used non-local broodstock and 63 percent transferred or released fish from outside the stream system. In contrast, 91 percent of integrated programs used broodstock derived from within the subbasin and 81 percent avoided transfer or release of fish from outside the subbasin.
- *Distribution of Hatchery Releases*: Hatchery managers reported planned releases of 235,690,000 juvenile fish of all species from hatchery programs in the U.S. portion of the Columbia River Basin. Approximately 88 percent or 207,734,500 fish are planned releases of anadromous salmonids below the fish passage barriers at the Chief Joseph and Hells Canyon dams. The largest proportion (42 percent) occurs in the Lower Columbia Province, as a result of earlier attempts to provide fish for the ocean and lower river commercial fisheries.
- *Goals and Purpose*: Harvest remains the primary reason for hatchery programs in the Columbia River Basin. This is particularly the case in the lower river; the purpose of upper river programs appears more evenly divided between harvest and conservation.
- *Funding*: Identification of hatchery funding is a complex issue because most programs are funded from a variety of direct and indirect sources. The Lower Columbia province has the most funding because it has the majority of programs.

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[1] An integrated program uses an open production cycle in which the hatchery population is combined with the natural population to form a single aggregate population.

[2] A segregated stock is intended to have minimal influence from and on surrounding natural stocks; interbreeding between hatchery and wild fish is minimized.

- *Monitoring and Evaluation*: Monitoring and evaluation consists primarily of reports of typical fish statistics such as number of recruits per spawner, smolt-to-adult survival, escapement, and total catch. Even so, many programs did not collect information for any of these categories. Information on the number of recruits per spawner was collected for less than 5 percent of programs, smolt-to-adult survival figures were available for 35.6 percent of programs, escapement figures were collected for 20.7 percent of programs, and about 33 percent of programs had information on escapement.

The APRE was designed to address concerns that the Columbia River Basin hatchery system needed to be reformed. The study applied hatchery reform principles developed by the HSRG to the information received from the fishery and hatchery managers. These principles included the following:

- Goals for stocks affected by hatcheries must be clearly articulated, expressed in terms of resource values, and reflective of current biological, economic, and cultural circumstances.
- Hatchery programs must be scientifically defensible.
- Decision-making about hatchery programming and operations must be responsive and well-informed.

When these principles were applied, a number of questions arose about artificial production within the Basin. These questions explored such issues as whether or not hatchery programs can be used more strategically to better accommodate ecological and social goals and how many hatchery fish should be released each year. Broad answers to these questions were formulated and used to arrive at the general conclusions of the study:

- Hatcheries are limited in what they can accomplish.
- The social, economic, and ecological purposes upon which the current hatchery programs were established have changed and will continue to change.
- Hatcheries will continue to play a part in recovery and management of fish in the Columbia River and elsewhere.
- Hatcheries require reform to align their policies and practices with current social priorities and scientific knowledge, to determine hatchery performance, and to operate in a business-like fashion.

CONTENTS

EXECUTIVE SUMMARY …………………………………………………….………… II

LIST OF TABLES…………………………………………..…...………………..VII

LIST OF FIGURES……………………………………………………………... VIII

CONTRIBUTORS ……………………………………..………………………… IX

ACKNOWLEDGEMENTS ………………………………………………………..X

ACRONYMS AND ABBREVIATIONS ………………..…………………… XI

GLOSSARY …………………………..………………………………………XIII

Chapter I: Introduction ………………………………………………..........1

I.A Purpose of APRE 1

I.B Background 3

I.C Need for Review of Artificial Production 5

I.D Scope of the APRE...6

I.E APRE Process 7

I.F Organization of the APRE Report 7

CHAPTER II: CONTEXT OF THE APRE ……………………………......13

II.A History and Social Context of Artificial Production.....................................11

II.B Legal Aspects 13

II.C Economic Context of Hatcheries 17

Commercial Value 17

Recreational Value 19

Existence Value 19

II.D Harvest 20

Columbia River Commercial Harvest History...20

Fisheries Management 20

Pacific Salmon Commission 21

Pacific Fisheries Management Council 21

Columbia River Compact 21

U.S. v Oregon 21

Fisheries...22

Impacts of Hatcheries on Fisheries...24

II.E Regulatory Context for Artificial Production....27
Council Guidance....27
NOAA Fisheries Guidance....29
II.F Biological Context....31
Environmental context....31
Ecological context....31
Genetic Aspects....35
Chapter III. Methods....38
III.A Premises....38
III.B Approach....39
Step 1. Information gathering....39
Step 2. Evaluation....40
Step 3. Reporting and Accountability....41
CHAPTER IV. RESULTS....43
IV.A Fish Stocks....43
IV.B. Hatchery operations....45
Type of operation.....45
Evaluation of Hatchery Practices.....49
IV.C. Distribution of Hatchery Releases....50
IV.D. Goals and purpose....52
IV.E. Funding....53
IV.F Monitoring and Evaluation....55
CHAPTER V. DISCUSSION AND CONCLUSIONS....56
Hatchery reform principles....56
REFERENCES....65
APPENDICES....69
Appendix A. Scientific Framework
Appendix B. APRE Questionnaire, Form 1
Appendix C. APRE Questionnaire, Form 2
Appendix D. Excerpts from APRE Database
Appendix E. Province Reports

List of Tables

		Page No.
Table II-1:	Relationships among artificial production programs and the regulatory framework	14
Table II-2:	Relationships relationships between habitat condition and artificial production strategies specified in the Council's 2000 Fish and Wildlife	28
Table III-1:	Example of APRE web-based evaluation report for a hatchery program (Cowlitz Spring Chinook)	42
Table IV-1:	Number and production origin for anadromous salmonids, resident salmonids, and non-salmonid fish stocks identified by fishery managers in the U.S. portion of the Columbia River Basin	43
Table IV-2:	Monitoring and evaluation statistics reported for anadromous fish hatchery programs in the Columbia River Basin	55

List of Figures

		Page No.
Figure I-1:	Columbia River Basin	2
Figure I-2:	Hatcheries with in the U.S. portion of the Columbia River Basin	3
Figure I-3:	Provinces and subbasins within the U.S. portion of the Columbia River Basin	9
Figure II-1:	Aggregate harvest of Pacific salmon, 1950-2000	17
Figure II-2:	World salmon aquaculture production and average price, 1984-2001	18
Figure II-3:	Statistical zones in the Columbia River	23
Figure II-4:	Coho fishery exploitation rates	26
Figure II-5:	Spring Chinook fishery exploitation rates	26
Figure III-1:	APRE process for evaluation of information provided on harvest and conservation goals (Form 1) and hatchery operations (Form 2)	40
Figure IV-1:	Distribution of fish stocks identified by fishery managers within the U.S. portion of the Columbia River Basin	44
Figure IV -2:	Distribution of planned releases of anadromous salmonids by cultural practice (integrated versus segregated), by species and ecological province; A) planned releases in segregated programs, B) planned releases in integrated programs	48
Figure IV-3:	Distribution of planned hatchery releases by species across provinces	51
Figure IV-4:	Distribution of purpose among artificial production programs in the Columbia River Basin	52
Figure IV-5:	Funding and support for anadromous fish production programs in the Columbia River Basin	54

Contributors

Barr, John	Results
Fleming, Ian	Genetics
Harrison, John	Congressional Questions and Council Direction
Hemming, Nancy	Report Coordinator, Technical Editor
Jenkins, Kris	Graphics Design
Huppert, Dan	Economic Context
Lichatowich, Jim	History of Artificial Production and Social Role of Artificial Production
Malone, Kevin	Results
Marsh, John	Social Context-legal and Regulatory Context-legal
McConnaha, Chip	Senior Report Author
Mobrand, Lars	Senior Report Author
Norman, Guy	Harvest and Harvest Goals
Sasser, Stephen	Graphics Design
Smith, Stephen	NOAA Fisheries Guidance
Suzumoto, Bruce	NWPCC Project Manager

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(to be added later)

Acronyms and Abbreviations

APRE	Artificial Production Review and Evaluation
BPA	Bonneville Power Administration
CRFMP	Columbia River Fish Management Plan
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
HGM	Hatchery and Genetic Management Programs
HSRG	Hatchery Scientific Review Group
IHOT	Integrated Hatchery Oversight Team
ISAB	Independent Scientific Advisory Board
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NWPCC	Northwest Power and Conservation Council (formerly NWPPC)
NWPPC	Northwest Power Planning Council (former name of the NWPCC)
OFWC	Oregon Fish and Wildlife Commission
PFMC	Pacific Fishery Management Council
PST	Pacific Salmon Treaty
PUD	Public Utility District
SRT	Scientific Review Team
WDFW	Washington Department of Fish and Wildlife

Glossary

Adaptive Management	A scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as vehicles for learning. Projects are designed and implemented as experiments so that even if they fail, they provide useful information for future actions. Monitoring and evaluation are emphasized so that the interaction of the system's various elements are better understood.
Adipose	a small, fatty, fin-shaped projection behind the dorsal fin of certain fishes, such as trout and salmon, that lacks supporting rays
Anadromous	indicates fish which hatch in fresh water, spend part of their lives in salt water, and return to fresh water to spawn
Artificial Production	the concept of using artificial habitats to enhance the survival of one or more fish life stages with the intent of increasing the abundance of a fish population. In the case of APRE, the fish are species of salmon and trout (*Oncorhynchus spp.)*
Escapement	the number of salmon returning to the spawning beds
Fingerling	juvenile salmonids approximately the size of a finger (usually less than a year in age)
Fry	newly hatched fish generally less than an inch long
Hatcheries	facilities containing raceways, ponds, and incubators that form artificial fish habitats for fish
Hatchery Program	the release of a fish of a particular species or race, e.g., spring Chinook salmon, at a location within a subbasin or along the mainstem of the Columbia River
Heritable	that which can be inherited

Salmonid	fish in the family *Salmonidae*, especially the genera *Oncorhynchus* and *Salmo*, which include salmon and trout
Smolt	the seaward migrating stage of anadromous salmonids
Stock	a group of fishes, often a population, that is believed to constitute a unique genetic fishery resource
Subbasin	a major watershed that is a tributary to the mainstem Columbia River or the Snake River, e.g., the Yakima River
Terminal Fisheries	Fisheries which occur off the main river channel, in estuaries, or in tributaries and which are designed geographically to focus the harvest on those species or stocks that originated from the fishing area

Chapter I: Introduction

I.A Purpose of APRE

This report summarizes the results and conclusions of the *Artificial Production Review and Evaluation* (APRE) conducted by the Northwest Power and Conservation Council. In this review, the Council is responding to a Congressional request[1] to review all federally funded hatchery programs in the Columbia River Basin (Figures I-1 and I-2) and to develop a set of coordinated policies for the use of artificial production in the Basin. To make the review more comprehensive, the Council expanded the Congressional directive to include hatcheries supported by non-federal funds.

The Northwest Power and Conservation Council (formerly known as the Northwest Power Planning Council) was established under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) to, among other things, create a program to "protect, mitigate and enhance" fish and wildlife in the Columbia River Basin affected by development and operation of the Columbia River hydroelectric system. The Council's Fish and Wildlife Program (Northwest Power Planning Council 2000) directs funding of projects by the Bonneville Power Administration (BPA) including construction and operation of several hatcheries for salmon, trout, and other species. The program lays out Basin-level policies for the use of artificial production and establishes an overall role for hatcheries consistent with the Council's vision for restoration of fish populations in the Columbia River. In addition, the Council has recognized the influence of artificial production on the success of many aspects of its program and has spearheaded several efforts to coordinate the management of artificial production in the Columbia River.

Congressional and Council interest in a review of artificial production stems from scientific and policy concerns about the success of artificial production programs and how artificial production may affect other aspects of fisheries management. Artificial production of salmon and trout has been used extensively in the Pacific Northwest to enhance fish populations for well over 100 years (Bottom 1997). Despite this long and extensive use of artificial production, the National Research Council concluded that hatcheries had not been evaluated over the long term and that consequently their success or failure has not been demonstrated (National Research Council 1996).

The APRE partially addressed these concerns by conducting an in-depth evaluation of 227 individual salmonid hatchery programs throughout the U.S. portion of the Columbia River Basin. The review was designed to evaluate benefits and risks of hatchery programs based on responses to a set of structured questions posed to hatchery operators and managers. APRE cannot substitute for the kind of long-term scientific evaluation advocated by the National Research Council (NRC) and others; however, the results should provoke thoughtful

[1] U.S. Senate Energy and Water Development Appropriation Bill, 1998, Report 105-44.

Figure I-1: Columbia River Basin

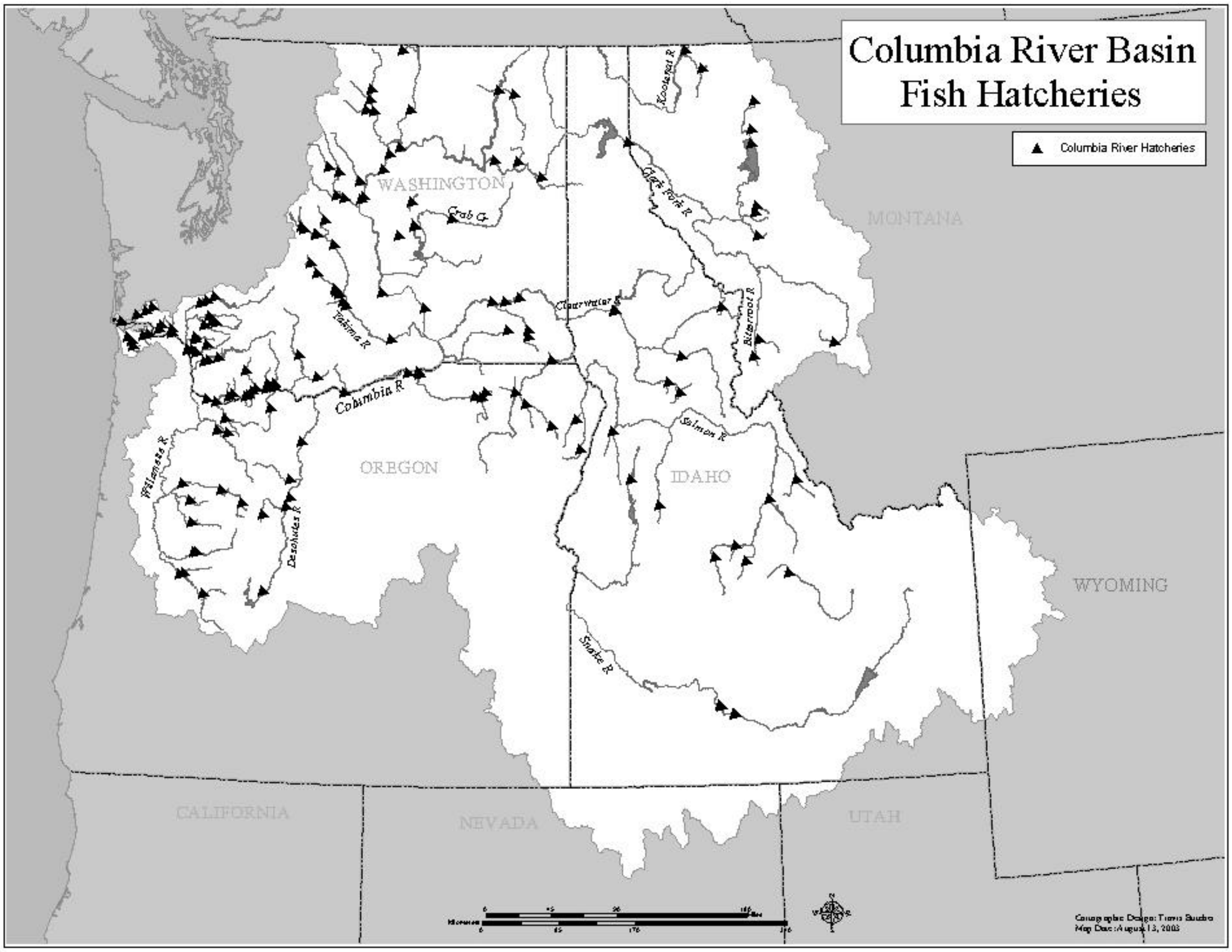


Figure I-2: Hatcheries within the U.S. portion of the Columbia River Basin

consideration of the future purpose and role of hatcheries in the Columbia River Basin and identify hatchery practices that contribute to the benefits and risks of hatcheries. It should also provide the basis for regional fisheries planning efforts by the Council and federal, state, and tribal management agencies.

I.B Background

In the July 1998 request from Congress, the Council was directed to recommend a coordinated policy for future operation of artificial production programs and to describe a process for developing policies in the future. Congress directed the Council to conduct its review with the assistance of the Independent Scientific Advisory Board (ISAB), a panel of 11 scientists who advise the Council and National Oceanic and Atmospheric Administration-Fisheries (NOAA Fisheries) on scientific issues related to fish and wildlife.

The Council, in coordination with the ISAB, appointed a Scientific Review Team (SRT) of experts in artificial production to provide an independent assessment of artificial production in the Columbia River Basin. In April 1999, the SRT submitted its review of scientific issues to the Council (Brannon et al. 1999). The Council also conducted an extensive public review of the team's conclusions that included input and comment from hatchery managers, tribes, environmental groups, recreational fishers, and others. The Council appointed a Production Review Committee to coordinate the artificial production review and assist it in developing artificial production policies. The Council also conducted public workshops and numerous public meetings to discuss artificial production, explain progress on the review, and to receive public comment.

The result of these efforts were collected into the Council's initial report to Congress (Northwest Power Planning Council 1999). In that report, the Council provided Congress with a set of artificial production principles and policies intended to "guide decisions on the use of artificial production for specifically defined purposes, based on scientific and management principles…" The Council included a set of science-based statements that form the Council's policy on the use of artificial production. These policies place artificial production in the context of the Columbia River natural-cultural ecosystem and recognize that use of hatcheries represent a social policy guided by scientific knowledge. The Council's artificial production principles and policies also provided a framework for organizing the purposes of artificial production programs.

The Council's report also described a process for implementing hatchery reform in the Columbia River Basin. This procedure relies on the Council's fish and wildlife program amendment process, including subbasin planning (see below and Section I.F), as the means to develop the purpose for future artificial production in the region. To move its proposals forward, the Council recommended to Congress the following six actions for implementing hatchery reform:

1. Identify the purposes for all artificial production facilities and programs and review these purposes relative to the Council's artificial production principles and policies
2. Evaluate the purposes of artificial production facilities and programs through fish and wildlife planning processes such as the Council's subbasin planning process
3. Use existing processes to implement artificial production reforms based on the Council's artificial production principles and policies
4. Ensure that funding is available to implement the Council's artificial production principles and policies
5. Form an *ad hoc* team to oversee the implementation of hatchery reforms consistent with the Council's artificial production principles and policies
6. Assess the success of the recommended reforms after five years.

APRE was the next step in the Council's artificial production review process and was prepared in response to the first of the Council's implementation recommendations. It identified the goals for each hatchery program and evaluated the benefits and risks of current operations compared to existing criteria derived from other regional artificial production reviews. The programs were reviewed in terms of their contribution to these purposes and their potential to adversely affect other priorities identified in the Council's goals and principles. Evaluation of the appropriateness of the purpose for each program was left to planning processes such as subbasin planning.

Subbasin plans will be developed as part of the Council's Fish and Wildlife Program. These plans are being developed for each of the 62 subbasins in the U.S. portion of the Columbia River Basin. They will be used as recommendations to the Council for funding priorities within the subbasins.

Recovery plans will be developed by the federal agencies for fish populations listed under the Endangered Species Act (ESA). Recovery plans for anadromous salmonids will be developed by NOAA Fisheries while those for resident salmonids and sturgeon will be developed by the U.S. Fish and Wildlife Service. These plans, which are being developed concurrently with the subbasin plans, will delineate the relationship between ESA-listed populations and hatchery programs through Hatchery and Genetic Management Plans (HGMPs). The HGMPs will establish sets of individual hatchery operations to minimize impacts on ESA-listed populations. The Council and the federal managers are working together to coordinate activities and avoid duplicative planning processes. For this reason, the APRE was structured to also provide the basis for development of HGMPs. APRE will produce partial draft HGMPs that will be revised through the federal process.

The Council's APRE has benefited from other reviews of artificial production, particularly the ongoing review in Washington State. That Congressionally mandated review has evaluated hatcheries in Puget Sound and on the Washington coast. The Washington review has been led by the Hatchery Scientific Review Group (HSRG), which is composed of independent scientists familiar with artificial production issues. The HSRG developed guidelines for hatchery reform and has successfully used them to evaluate a variety of hatchery programs in Puget Sound and on the Washington coast. The Columbia River APRE built on the work of the Washington State HSRG and has employed the HSRG guidelines to evaluate hatchery practices in the Columbia River (Section III.B).

In addition, APRE drew on the work of the Council's Integrated Hatchery Operations Team (IHOT) in the Columbia River Basin. IHOT developed and implemented hatchery review procedures to audit most hatcheries in the Basin.

I.C Need for Review of Artificial Production

Artificial production of anadromous and resident salmonids is a fisheries management technique that has been used throughout the Columbia River Basin and the Pacific Northwest for over 100 years (Section II.A). Hatcheries were initially used as a means to avoid the need for restrictive harvest regulations that were deemed politically infeasible. Later, hatcheries were constructed in the hope that abundance and harvest rates could be maintained even as dams and other activities degraded and eliminated freshwater habitat (Bottom 1997). Hatcheries have proliferated throughout the Basin and returns of adult fish to hatcheries and fisheries in the Columbia River now greatly exceed the return of naturally spawning fish. Arguably, hatcheries have allowed continuation of commercial and sport harvest of salmon and trout in the face of massive and widespread environmental degradation.

Now, however, the use of hatcheries is being reassessed. Over the past several years, reviews of Columbia River hatcheries have questioned the scientific basis for current programs and uniformly concluded that change is needed, e.g. National Research Council 1996, Brannon et al. 1999, and Independent Scientific Group 2000. Many hatchery programs were developed under an agricultural conceptual foundation in which hatcheries selected for domesticated traits and isolated fish from the perceived inefficiencies of the natural world (Bottom 1997). This view is inconsistent with prevailing scientific concepts of ecosystems and species functions, and many scientific reviewers have called for a new conceptual foundation for fisheries management (Brannon et al.1999, Independent Scientific Group 2000). The National Research Council (1996) noted that the scientific basis for artificial production is not clear and that adverse impacts from artificial production can occur. They went on to say that "Most artificial production programs have not undertaken long-term evaluation and documentation of the extent to which intended goals were reached (e.g., increase the catch for a given population, prevent extinction of populations whose spawning grounds were destroyed by dams) and unintended risks were imposed (e.g., adverse genetic or ecological impacts on naturally reproducing fish)." There is great concern about whether or not artificially produced fish adversely affect naturally spawning populations of fish (National Research Council 1996, Flagg et al. 2000).

In addition, the economics of fishing, as well as societal views on the value of natural resources, have shifted since the mid-20th century when many existing hatchery programs were conceived. The role of hatcheries is less certain today (Bottom 1997). The commercial salmon fishing industry is undergoing rapid change, while recreational fishing is assuming a greater priority for fishery managers. Society now attaches intrinsic value to salmon in addition to their commercial value indicating a need to realign hatchery purposes with societal needs. These considerations dictate the need for a thorough review of the application of artificial production. This is especially important because of the efforts by the Council (through subbasin planning) and the federal agencies (through Endangered Species Act recovery planning) to develop long-term, strategic plans for fisheries management in the Columbia River Basin.

I.D Scope of the APRE

The purpose of the APRE was to evaluate the benefits and risks of current hatchery programs in the U.S. portion of the Columbia River Basin as a foundation for regional planning efforts by the Council, federal managers, and others. A fundamental premise of the APRE was to use information freely provided by the fishery managers. On the basis of such information, the project identified the purposes for hatchery programs and looked at how current hatchery programs are contributing to these purposes. Although information was provided for a variety of native and non-native fish species, the most complete information was provided on anadromous salmonid programs. Because of this, the summary provided in this report focuses on anadromous salmonid programs; however, it is emphasized that information on additional programs is available in the APRE database. The APRE focused on programs in the U.S. portion of the Columbia River Basin for hatcheries supported by federal, state, tribal, and private funds and which are producing anadromous salmonids. For each hatchery program, the extent to which the program was meeting its stated purpose (benefit) was evaluated along with the extent to which the program may be negatively impacting other populations and priorities (risk). This implies that each hatchery program has a clearly stated purpose, an assumption that was not always valid and which itself forms an important aspect of the evaluation. The evaluation addressed only generally the appropriateness of the purposes of hatchery programs in the present economic, social, and scientific context. These are more properly addressed through the Council's process, including subbasin planning, and through other state, federal and tribal policy processes.

Information on each program was collected through a series of regional workshops using a standardized questionnaire. The questionnaire collected descriptive information on each program, summarized what the managers stated to be the purpose of the program, and described the program's relationship to activities and fish populations within the subbasin. Information has been compiled on a web-based system that provides access to hatchery information providing a resource for hatchery management in the Columbia River Basin. The information base is far from complete due to a lack of basic information about many programs. As information is collected in the future, it can be added to the information base to form a more complete description of ongoing hatchery practices.

I.E APRE Process

The APRE review process was based on the hatchery review developed by HSRG in Washington State and the IHOT process in the Columbia River Basin (Section III.B). This allowed the APRE to build on the extensive scientific and public review process developed in Washington and to use products that had a record of successful use in reviewing similar hatchery programs. The APRE process evaluated information on current hatchery goals and operations in the Columbia River against the HSRG/IHOT criteria that were used to define the APRE working hypothesis.

To establish its review criteria, the HSRG identified requirements which must be met for hatcheries to successfully contribute to harvest and conservation goals. These requirements and their scientific bases were reviewed by more than 200 scientists and stakeholders and ultimately led to the development of guidelines that reflected current scientific knowledge and fish husbandry practices (HSRG 2002, www.hatcheryreform.org). Based on these guidelines, the HSRG developed a set of questions for its review of Puget Sound and Washington coastal hatcheries. The HSRG review questions, as well as questions from the federal HGMP template and the IHOT review, were used to develop the APRE hatchery questionnaire. The questionnaire collected information on hatchery goals and operations from the hatchery managers and operators. Responses to the questionnaire were collected in a web-accessible database containing the basic evaluation data for the APRE (www.apre.info) and evaluated against the APRE premises (Section III.A).

I.F Organization of the APRE Report

The results of the APRE project have been organized using the ecological framework presented in the Council's Fish and Wildlife Program (Northwest Power Planning Council 2000). This is a hierarchical structure for organizing fish restoration efforts intended to reflect underlying ecological patterns across the Columbia River Basin. The Council's framework organized the Columbia River Basin into ecological *provinces* and *subbasins*. Provinces are groups of subbasins (e.g., the Columbia Plateau), sharing similar climate, geology, and biogeography (i.e., similar plant and animal groups). The Council has defined 11 Ecological

Provinces within the Columbia River Basin (Figure I-3). These provinces contain 62 individual subbasins. A subbasin is a major watershed that is a tributary to the mainstem Columbia River or Snake River, e.g. the Yakima River. Hatcheries are located within subbasins and hatchery programs (see below) represent releases of fish at a specific location within a subbasin.

This **Basin level report** contains a synthesis of the APRE conclusions. The Basin level report looks at trends in artificial production across the Council's ecological provinces. It includes results, discussion, and general conclusions from the APRE review to date. Recommendations will be formulated following a public review of the Basin level report. Attached to the Basin level report is a series of **Ecological Province reports**. These province reports are structured similarly to the Basin level report, but report results across subbasins within each province. Attached to the subbasin reports will be the **individual program reports** for the hatchery programs in each province. The individual program reports identify the stated purpose for each program and the contribution of the program to these purposes. They also provide an assessment of the current operations of the hatchery contributing to the program relative to prevailing fish cultural practices. These individual program reports, which are intended to be a resource for hatchery managers, are generated from the web-based APRE information system and can be reviewed and updated into the future. They allow comparison of artificial production across subbasins to identify provincial level purposes and highlight similarities and differences between subbasin artificial production programs.

I.G Definitions

The terms defined here are essential to understanding the APRE approach, results, and conclusions. Definitions of additional terms may be found in the Glossary which appears on page xii.

The APRE defines a *hatchery program* as production of a "like" group of fish which spends some portion of its life cycle in a hatchery environment and is released at a location within a subbasin or along the mainstem Columbia River. A hatchery program was identified by species, stock, and release location. A hatchery facility may contribute to several hatchery programs and a hatchery program may involve more than one hatchery for different rearing phases.

A group of fish delineated by the fishery managers on the basis of management purpose is termed a *stock*. Because of the management implications in this definition, fish are often divided into hatchery and natural stocks. A *population* is a group of fish delineated on the basis of genetic affinity. A population may include both hatchery and natural components

Figure I-3: Provinces and Subbasins within the U.S. portion of the Columbia River Basin

if the fish are believed to represent a common evolutionary legacy and have a close genetic relationship. A group of related populations is termed an Evolutionarily Significant Unit (ESU) under the Endangered Species Act (Waples 1995). An ESU is a legal and management notion that draws on the scientific concept of a *metapopulation*, which is a group of local breeding populations occupying distinct habitat patches that are genetically connected by patterns of migration and straying (Hanski and Simberloff 1997)

Two types of programs, integrated and segregated, were recognized in the APRE based on the intended amount of genetic connection to naturally spawning fish. *Integrated* hatchery programs are "open" systems designed to combine hatchery and natural components into a single stock or population. Integrated programs minimize the divergence of the hatchery population from its natural counterpart. In an integrated program, the hatchery is viewed as an artificial extension of the natural environment. Brood stock includes progeny from natural and hatchery spawners and the intent is to minimize genetic divergence of the combined natural-hatchery population from the original natural population. Integrated programs are often referred to under the general heading of supplementation. This term was avoided in the APRE because it was considered to be a less precise term for designating hatchery programs which are integrated with natural populations.

Segregated programs are “closed” systems in which the hatchery is a distinct stock which has minimal interaction with natural population components. Segregated hatchery programs are designed to minimize the genetic interaction of the hatchery population with natural populations. Brood stock in a segregated program typically consists of progeny from adults of the same hatchery. Genetic divergence from natural populations may be allowed and, in some cases, encouraged through selection for traits and behavior.

Chapter II: Context of the APRE

Hatcheries have been used as tools to achieve societal objectives. These objectives evolve through time in response to changes in cultural and legal priorities, reordering of social mores, and improved scientific knowledge. Therefore, in order to effectively manage hatcheries in the future, it is necessary to understand hatcheries in the context in which they were conceived which may be quite different from the context in which they currently exist.

II.A History and Social Context of Artificial Production

Artificial propagation of Pacific salmon began in 1875 with construction of the McCloud River Hatchery in California. Two years later, the first hatchery in the Columbia River Basin was built on the Clackamas River. This event marked the beginning of an approach to salmon management in the Columbia River Basin that has persisted to the present (Lichatowich 1999).

In 1875, the salmon canning industry in the Columbia River Basin was rapidly becoming an important part of the regional economy. Business and political leaders were worried about maintaining a supply of salmon; they were well aware of the earlier collapse of the Atlantic salmon fishery. Spencer Baird, the newly appointed head of the U.S. Commission on Fish and Fisheries correctly identified the threats to the supply of salmon: habitat change, excessive harvest, and dams or other barriers to migration (Baird 1875). However, he concluded that effective regulations could not be enacted or enforced to avoid or reduce these threats, so he offered an alternative: fish culture. The alternative was accepted with enthusiasm, because it was perceived that habitat alterations and harvests could continue with few regulations or restraints.

Baird's conclusion, however, was offered in the absence of supporting scientific information. The McCloud River hatchery and the fledging Columbia River hatchery program were begun with no scientific studies indicating their possible success. This did not deter hatchery enthusiasts who embraced the concept as being in keeping with two prevailing 19th century ideologies toward exploitation of natural resources. The first was that there should be free access to natural resources. Therefore, if hatcheries produced salmon for commercial harvest, that harvest could continue unhindered by concern about the effects of overfishing, construction of dams, or other development. The second ideology was the belief that nature must be controlled and manipulated for human benefit. Ancillary to this was the belief that humans could always improve on natural processes (Bottom 1997).

Both attitudes excluded the idea of failure. As stated in Lichatowich (1999), technology derived from ideology is never allowed to fail. As a result, signs of failure are overlooked until problems can no longer be ignored. It appears that this was the case with hatchery evaluation as hatcheries were constructed and operated for decades with little or no scrutiny.

Artificial propagation of salmonids in the Columbia River Basin from 1875 to the present can be divided into three phases based on hatchery purpose and primary culture technique. From the late 19th century to the 1930s, the major purpose of hatcheries was to support commercial harvests which had been reduced by high harvest rates and habitat loss. The primary culture technique was to release unfed fish fry. By the 1930s and continuing to the 1970s, the purpose shifted to mitigation for habitat loss caused by development and operation of hydroelectric dams. Large production hatcheries were segregated from natural populations and fish were released at the smolt stage. Since the 1970s, the role of hatcheries has shifted to conservation of natural populations. Artificially propagated salmon and trout are provided for recreational and tribal use and, to a lesser degree, commercial harvest. Culture techniques have been expanded to supplement wild fish populations with hatchery fish. Captive programs to conserve genetic resources have also been instituted (Section II.F).

In the first phase of hatchery development, proponents of salmon culture were slow to recognize the need to determine if hatcheries were meeting their goals. As early as 1903, it was recognized that fish culturists lacked scientific information about salmon biology, which was needed for effective salmon propagation (Chamberlin 1903). However, it was not felt that this necessarily reduced the chance of success. Chamberlin (1903) stated that "Until the salmon industry or the people choose to pay for careful, expensive investigation, propagation must be taken on faith."

In 1922, the first study to determine if hatcheries had contributed to the annual returns of salmon was conducted. Rich (1922) performed a statistical analysis of hatchery releases and adult returns and concluded that he could find no evidence that hatcheries had increased the abundance of adult salmon.

The second phase of hatchery development in the Columbia River began in 1933 with construction of the Rock Island Dam, the first dam built in the mainstem Columbia. The U.S. Congress authorized the Bonneville Dam that same year; two years later, Grand Coulee was given Congressional approval. The problem of getting adult salmon over high mainstem dams had not been completely solved, leading to concern over the fate of upriver salmon stocks. Artificial propagation was proposed as a solution to impassable dams and as mitigation for lost habitat above the dams. This idea, however, had not yet been proven.

The primary goal of hatchery programs during the second phase was to support the commercial salmon fisheries in the lower Columbia River and in the ocean off Oregon and Washington. It made little sense, therefore, to fisheries managers to locate hatcheries in the upper part of the Columbia River Basin where fish would have to contend with passage problems at mainstem hydroelectric projects. In order to mitigate for lost upriver fish habitat, hatcheries in this period were built around and below Bonneville Dam. This deprived Indian tribes and other upriver fishing interests of compensation for habitat loss and eventually led to litigation by the treaty tribes (Sections II.B).

During the second phase of hatchery development, a few experiments of limited scope were carried out (summarized in Brannon et al.1999). The early studies, which generally reported favorable results, mainly focused on determining the number of returning adult salmon of hatchery origin and/or their contribution to the fisheries. Whether or not hatcheries were meeting their goals to maintain historical abundance or to mitigate for specific lost habitats was not scrutinized. In addition, the studies did not explore the question of whether the presence of hatcheries on a system was detrimental to natural production of fish. Indeed, the idea of the intrinsic and environmental value of natural fish was not considered.

Hatcheries began using improved diets and better disease treatments during the late 1950s. These, coupled with favorable ocean conditions, resulted in greatly increased production of adult salmon. During the 1960s, increasing numbers of fish were released from programs in the Columbia River and elsewhere with the expectation of nearly boundless harvest. The dramatic decline of salmon abundance in the Pacific Northwest in the early 1970s (Pearcy 1992) dispelled this idea and led to a re-examination of the purpose of hatcheries, ushering in a new phase in hatchery development.

The third (and present) phase of hatchery development in the Columbia River Basin began in the late 1970s and has been marked by a new valuation of natural resources resulting from the growth of the environmental ethic in the United States. It has also been marked by a realization that, despite massive efforts to bolster salmonid populations through artificial production, salmon and steelhead abundance continued to decline. This led to a new questioning of the role of hatcheries and an effort to give artificial propagation a scientific foundation. In addition, the Endangered Species Act highlighted the decline of salmonid populations as an issue of national concern. As a result, hatcheries in the Basin are assuming a new role in recovery and conservation of imperiled stocks. Many newer hatcheries are augmenting depleted salmon and steelhead populations with artificially propagated fish while other new hatcheries are employing captive brood technology to rebuild depleted populations. Conservation, rather than harvest, is the primary goal of these new hatcheries, although harvest most likely will regain importance if the hatcheries prove successful. The newer hatchery programs, unlike their predecessors, are being subjected to a higher level of scrutiny.

The fisheries of today's Columbia River Basin are products of management decisions over the past 127 years. Hatcheries have been slow to respond to changes in societal values and to scientific insights. Inevitably, they are imperfect solutions to past problems. Yet hatcheries are likely to be part of any fisheries management plan for the Columbia River Basin. In the mainstem and in many subbasins, salmonid habitat has been lost and is not likely to be recovered under any feasible alternative. Populations of salmonids have been negatively affected in a number of ways. In addition, the federal government has treaty obligations to Indian tribes to provide harvest opportunities in areas where fisheries have been diminished or lost to development activities. In these cases, hatcheries may provide the only mitigation option.

II.B Legal Aspects

Hatcheries are managed by a complex array of treaties, laws, and policies. The legal requirement for artificial production addresses the need to replace or mitigate losses of fish caused by degradation or elimination of habitat as well as to uphold obligations under international and tribal treaties and the Endangered Species Act. Table II-1 summarizes the various mitigation settlements that have resulted in construction and operation of hatcheries in the Columbia River Basin.

Since the beginning of the dam construction era in the Columbia River in the 1930s, artificial production in the Columbia River Basin has been tied primarily to mitigation for habitat loss, especially due to the construction of the hydropower system. Large portions of the Columbia River were eliminated from salmon and steelhead production by Grand Coulee (mainstem Columbia River) and Hells Canyon (mainstem Snake River) dams. Other dams have led to the loss of nearly all mainstem spawning habitat in the Columbia River above Bonneville Dam with the exception of the Hanford Reach. Hydropower dams in tributaries such as the Deschutes, Clearwater, Okanogan, White Salmon, Lewis, Cowlitz, and Willamette subbasins also blocked access to important habitat. In order to mitigate for these habitat losses and maintain fish abundance, numerous hatchery programs have been developed.

Artificial Production Program	Establishing Mechanism	Type of Program	Responsible Entity
Columbia River Fishery Development Program	Mitchell Act of 1938	federal dam mitigation	NOAA Fisheries
Lower Snake River Compensation Plan	Water Resources Development Act of 1976	federal dam mitigation	U.S. Fish and Wildlife Service
Grand Coulee Dam Mitigation		federal dam mitigation	U.S. Bureau of Reclamation
Dworshak Dam Mitigation	Flood Control Act of 1962	federal dam mitigation	U.S. Fish and Wildlife Service
John Day Dam Mitigation	Agreement between COE, Oregon and Washington	federal dam mitigation	Mitigation provided at Mitchell Act Facilities
Willamette River Basin Dams Mitigation	River and Harbor Flood Control Act of May 17, 1950	federal dam mitigation	Oregon Department of Fish and Wildlife
Cle Elum, Umatilla, Northeast Oregon, Walla Walla River, Nez Perce Tribal artificial production programs	Pacific Northwest Electric Power Planning and Conservation Act of 1980	Columbia River Basin Fish and Wildlife Program	Various tribes, states and federal agencies
Hells Canyon Project Mitigation	Hells Canyon Settlement Agreement of February 14, 1980	FERC license	Idaho Power Company
North Fork Lewis River Mitigation	FERC licenses	FERC license	PacifiCorp
Condit Dam Mitigation	voluntary	voluntary	PacifiCorp
Bull Run and North Fork Projects Mitigation	FERC licenses	FERC license	Portland General Electric Company
Deschutes River Mitigation	FERC license	FERC license	Portland General Electric Company
Cabinet Gorge Kokanee Hatchery	voluntary	voluntary	Avista Corporation
Wells Dam Mitigation	FERC license	FERC license	Douglas County PUD
Rocky Reach Dam Mitigation	FERC license	FERC license	Chelan County PUD
Priest Rapids and Wanapum Dams Mitigation	FERC license	FERC license	Grant County PUD
Swift II Project Mitigation	FERC license	FERC license	Cowlitz County PUD
Mayfield and Mossyrock Project Mitigation	FERC license	FERC license	Tacoma Public Utilities

Table II-1: Relationships among artificial production programs and the regulatory framework

The first legally mandated artificial production program in the Basin was initiated under the Mitchell Act of 1938. This act provided funding for efforts to address the general decline of harvest and fish populations in the Columbia River Basin resulting from impacts of water diversions, mainstem dams, deforestation, and pollution. It did not, however, tie project funding to fish losses attributable to any specific locations or activities, or to obligations to address the importance of the fish loss to any particular human populations. The Mitchell Act (amended) paid for construction of the large production facilities in the Lower Columbia River such as Little White Salmon, Willard, Carson, and Spring Creek hatcheries. The program provides federal funding for hatcheries through the Department of Commerce to the states of Oregon, Washington, and Idaho and the U.S. Fish and Wildlife Service.

The Lower Snake River Compensation Program provides compensation for habitat lost to construction of the four lower Snake River hydroelectric projects. The program, which originally was funded through Congressionally appropriated funds reimbursed by BPA, is now funded by BPA directly and operates 27 hatchery facilities in Idaho, Oregon, and Washington.

Private firms provide mitigation hatcheries as well. Idaho Power Company funds the construction and operation of hatcheries in Idaho to compensate for construction of Hells Canyon Dam Complex. Public Utility Districts (PUDs) operate dams in the mid-Columbia and in several tributaries and fund mitigation hatcheries which are usually operated under agreements negotiated with the Federal Energy Regulatory Commission (FERC).

One effect of artificial production mitigation activities has been to change the location of fish production in the Columbia River Basin. To compensate for dams that completely block access, it is not possible to provide in-place mitigation. Consequently, salmon mitigation hatcheries have often been located in other areas of the Basin where migration has not been blocked. Many of the largest mitigation hatcheries were constructed in the mid-20th century when the primary goal was to support the commercial fishing industry off Oregon, Washington and in the lower Columbia River. Therefore, it made little sense to mid-20th century hatchery planners to locate hatcheries upriver where the fish produced would be subjected to mortalities imposed by the dams. Consequently, many federally funded hatcheries whose purpose was to mitigate for the loss of upriver fish habitat were constructed downstream of Bonneville Dam or in other areas away from where the production was lost. Tribal and non-tribal communities in areas no longer accessible to fish are deprived of resources that were used for religious, cultural, and economic purposes.

This problem is particularly acute for the non-Treaty tribes in the upper Basin near or above the impassible dams for whom salmon were completely denied and who received no benefit from downriver mitigation hatcheries. The four Treaty Tribes below the impassible dams (Yakama, Warm Springs, Umatilla, and Nez Perce) were provided some mitigation from facilities such as the Leavenworth Complex, but for many years, the practice of placing mitigation hatcheries in the lower river limited mitigation benefits to the Treaty Tribes and other upriver interests. To address this issue, a significant number of fish produced at down-river hatcheries are now transported upriver and released. The fish management plan developed as a result of the *U.S. v Oregon* court case was the impetus for the transport of artificially produced fish to upriver release locations. This practice is on-going since 1980; however, such stock transfers are now considered a questionable practice on biological grounds and they remain an imperfect solution to an important social and legal issue.

The loss of fishing opportunity for the Treaty Indian Tribes in the Columbia River due to habitat loss and management decisions led to court decisions that have radically changed fishery management throughout the Pacific Northwest. In 1969, a federal court determined in *U.S. v Oregon* that the Yakama, Warm Springs, Umatilla, and Nez Perce tribes retained fishing and hunting rights under their treaties and that the states had limited management authority over tribal fishing. The treaties were interpreted to guarantee the tribes 50 percent of the harvest of fish destined for tribal fishing areas and the right of the tribes to the management of their own natural resources. However, mainstem hydroelectric projects, agriculture, and other development have severely eroded the natural capability to support these rights and the tribal fisheries. The tribes have pursued hatchery programs to support their treaty rights and subsistence, ceremonial, and commercial harvests. Several tribally managed hatchery programs have been developed above Bonneville Dam under the Council's Fish and Wildlife Program as hydropower mitigation. The tribes have become leaders in the development of hatchery programs that attempt to be compatible with current scientific information on genetics and ecological processes.

The Endangered Species Act of 1973 was established by Congress with the purpose of providing "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved [and], to provide a program for the conservation of such endangered species and threatened species…" Threatened and endangered species under the Act have been interpreted to include significant population segments that, for salmonids, have been defined as Evolutionarily Significant Units (Waples 1995). An ESU is a fish population or group of populations that "(1) is substantially reproductively isolated from other conspecific [fish of the same species] population units, and (2) represents an important component in the evolutionary legacy of the species."

There are now 12 Columbia River Basin ESUs listed as threatened or endangered. An additional ESU (lower Columbia/SW Washington coho) was designated as a candidate species in July 1995. In addition, numerous other listed or candidate ESUs along the California, Oregon, and Washington coasts affect ocean fisheries that may harvest Columbia River salmonids. Because of the ESA status of many Columbia River salmonids, harvest managers must consult annually with NOAA Fisheries to assure fishers are regulated to meet "no-jeopardy" standards established for ESA-listed species. NOAA Fisheries issues incidental take permits to regulatory agencies and tribes for fisheries which have satisfied ESA regulatory requirements.

Current management of artificial production is substantially impacted by the legal obligations under the Endangered Species Act. As discussed Section II.F, hatcheries can have negative effects on wild fish populations. In response to the ESA, the potential impact of hatcheries on listed populations must be evaluated through HGMPs developed for each hatchery operation. The use of artificial production in recovery of listed fish populations and how these practices comply with the legal mandates of ESA are being debated in the legal and scientific community. While the statutes and agreements that fund these programs allow artificial production for this purpose, the ESA is not clear under what circumstances it is appropriate. Regardless, artificial production practices have been modified in some instances to assist in recovery of listed populations. In addition, some listed populations have been captured and put into hatcheries in order to boost survival and avoid potential extirpation.

The legal basis for artificial production of fish populations is straightforward; it is based on the replacement of lost fish for purposes related to religious, cultural, and harvest concerns and, increasingly, conservation. Implementation is often compromised, however, by conflicting mandates and the complexity of legal debate. The social and legal questions that remain include the geographic location of mitigation programs and the use of artificial production to address the requirements of the Endangered Species Act.

II.C Economic Context of Hatcheries

Many of the hatchery programs in the Columbia River Basin were developed during the mid-20th century for the purpose of supporting commercial fishing in the face of dwindling wild fish stocks. For several decades, Columbia River hatcheries sustained commercial and sport fisheries off Oregon, Washington, British Columbia, and southeast Alaska. Today, the economics of commercial fishing are changing. Understanding the role of hatcheries in a changing economy requires understanding the economic basis of fisheries.

Commercial Value

For most of the 20th century, salmon produced from the Columbia River supported a vibrant ocean fishing industry that extended from Northern California to southeast Alaska. However, over the past two decades, the commercial salmon fishery has been greatly affected by the burgeoning supply of fresh salmon from the salmon farming industry. As shown in Figure II-1, the aggregate harvest of Pacific salmon remained at relatively high levels (mainly in Alaska), while world farmed production grew to exceed the total fishery harvest.

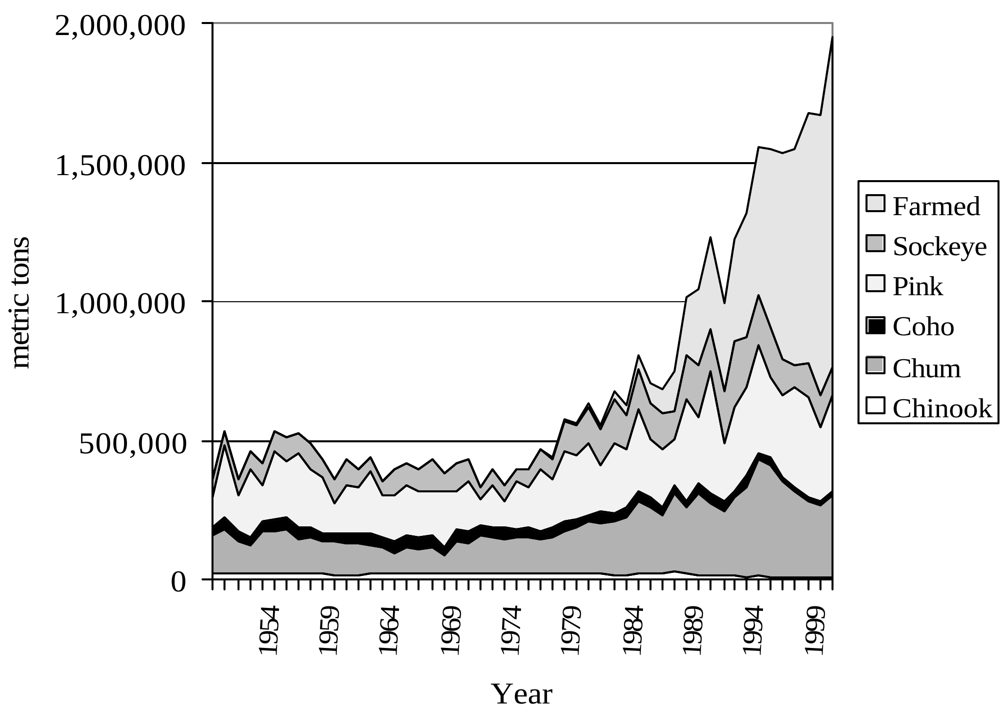


Figure II-1: Aggregate harvest of Pacific salmon, 1950-2000

One major consequence of this development was a substantial drop in the price paid to fishers for salmon. This drop in price affected both farmed salmon and harvests of wild salmon and occurred as a result of the rapid technological advances in salmon farming that fostered lower production costs and effective marketing techniques. The average market value of farmed salmon dropped from roughly $6,000/metric ton to less than $3,000/metric ton between 1987 and 2001 (Figure II-2). This worldwide trend in price is the major cause of reduced earnings and the resulting economic crisis for Columbia River, West Coast, and Alaskan fishing communities.

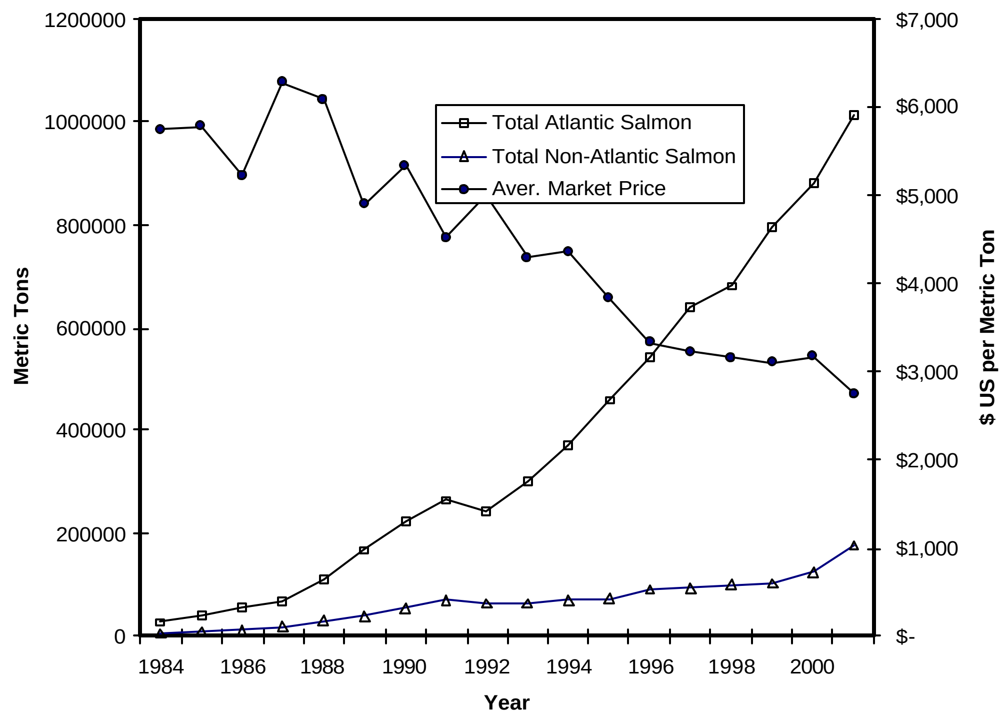


Figure II-2: World salmon aquaculture production and average price, 1984-2001. Source: FAO FishStats database, July 2003

Harvests in the ocean fishery north of Cape Falcon, Oregon, (the ocean area in which Columbia River fish are most frequently caught) fluctuated widely around a declining trend until an upturn in catch during the last two years. Between 1987 and 2002, the average price of salmon to the fisherman (coho and Chinook combined) dropped from roughly $5.00 per pound to just over $1.00 per pound (recent information from the 2003 fishery indicates that the price has further declined to less than $1.00 per pound). Similarly, the in-river gillnet commercial salmon fishery has suffered a substantial decline in total volume of harvests and price since the mid-1980s; current gillnetted coho salmon return about $0.50 per lb to fishermen. The reduced harvests during the mid-1990s did not bring a positive price response because the Pacific coast salmon are sold into an internationally supplied market that is affected by the increasingly important salmon aquaculture industry.

Rough estimates of the total value of the commercial fisheries in the lower Columbia and north of Cape Falcon areas are difficult to obtain. However, the Pacific Fishery Management Council has estimated an ex-vessel value for 2002 for the fishery north of Cape Falcon of $1,228,000. A commercial value of the fishery in the lower Columbia River non-Indian fishery for 2000 was $1,438,000 while the average for 1996-2000 was $641,730. The average over 20 years (1981-2000) was $4,884,020. All of these figures are stated in inflation adjusted 2002 dollars.

The trends in commercial fishing suggest that harvests of Pacific salmon from the Columbia River or ocean areas will make declining future contributions to the value of seafood supply and to local incomes. Further, any enhancement in run sizes for commercial harvests, whether due to hatchery operations or other factors, will make relatively small contributions to the economic value of seafood supply.

Recreational Value

The recreational fishery supported by Columbia River salmon includes the ocean fishery north of Cape Falcon, the estuary and lower river fishery, and various fisheries farther upstream and in tributaries. The ocean and lower river fisheries have been highly variable, both in terms of catch and in level of participation (as measured by annual angler trips taken). The ocean recreational catch averaged 137,000 fish (coho plus Chinook) during 1986-2002. The catch varied between 150,000 and 200,000 in the late 1980s and early 1990s, dropping to zero in 1994 then recovering to a respectable 232,000 in 2001. The lower river and estuary fishery had an average annual catch of 142,000 fish during 1981-2000. Like the ocean fishery, the river fishery catch was relatively high in the late 1980s and early 1990s, dropped to a record low in 1994, and recovered to about half of the earlier high levels in 2000. Recreational catch data for the river has not been released yet for 2001 and 2002.

Economists occasionally conduct economic surveys of recreational salmon fishers to determine the net value of recreational fishing, i.e., the value to anglers of fishing trips minus the cost of taking those trips. The most relevant study for Columbia River salmon fishing was conducted by Olsen, Richards, and Scott in 1991. In that study, the authors determined that the average net value per fishing trip in 1989 was $111.46, or $147.63 in 2002 dollars, in the Columbia River Basin, and $89.47 ($118.50 in 2002 dollars) in the Oregon-Washington coastal fishery. While these values will undoubtedly vary over time (especially as catch rate varies), they can be used to roughly gauge the value of the recreational fishery by multiplying angler days by this estimated average value. This procedure yields an average annual value of $11 million for the ocean recreational salmon fishery north of Cape Falcon (using data for 1986-2002) and an annual value of $27.3 million for the lower river/estuary recreational fishery (using recorded trips for 1981-2000).

Existence Value

Beyond economic values associated with recreational and commercial fishing, salmon are valued more broadly for their less tangible, but no less important, “existence values.” Existence value is reckoned as the amount that people would be willing to pay to assure the existence of a fish stock, or to pay for a specified increase in the fish stock. For example, Olsen, Richards, and Scott (1991) found that people who claimed no intention to catch or eat salmon from the

Columbia River were still willing to pay an average $26.52 per year per household ($35.12 in 2002 dollars) to obtain a doubling of the salmon run size. They estimated a total existence value to a doubling of salmon production of $70.2 million/year. Existence values apply to everyone who values the fish run, as contrasted with user values which accrue only to those catching fish in competition with others.

II.D Harvest

Until relatively recently, the primary goal of fisheries management in the Columbia River was to support and manage commercial harvest in the river and in ocean areas off Oregon and Washington. The existing Columbia River hatchery system was built largely to maintain commercial harvest in the face of widespread degradation and loss of freshwater habitat (Section II.A). In recent years, harvest has been increasingly constrained by conservation goals and a changing harvest economy. This section discusses the current harvest management goals and structure and their relationship to the Columbia River hatchery system.

Columbia River Commercial Harvest History

Columbia River Indians used salmon for thousands of years before the Europeans arrived. Europeans began using salmon about 1830 and, by 1861, commercial fisheries became significant. In 1866, salmon canning began in the Northwest, and the non-Indian commercial fishery grew rapidly. Salmon and steelhead landings exceeded 40 million pounds annually several times between 1883 and 1925 (WDFW-ODFW 2002).

Since the early 1940s, Columbia River commercial landings of salmon and steelhead have declined, reflecting declines in salmonid abundance. Treaty Indian commercial landings became a larger portion of the total Columbia River commercial landings following the 1969 *U.S. v Oregon* federal court ruling which confirmed Treaty Indian rights to an equitable share of the harvest.

In the early part of the 20th century, nearly all commercial fisheries operated in freshwater, where only mature salmon were harvested. Ocean fisheries became more important in the late 1950s as more restrictions were imposed on freshwater and coastal estuary fisheries. Ocean harvest of salmon peaked in the 1970s and 1980s. In recent years, ocean commercial and recreational harvest of salmon has generally been reduced as a result of international treaties, fisheries conservation acts, regional conservation goals, and state and tribal management agreements.

Fisheries Management

Pacific salmon and steelhead are exposed to fisheries along most of the west coast of North America. Because they cross national and state boundaries, their management is governed by a number of organizations. All fisheries of the Columbia River are established within the guidelines and constraints of the Pacific Salmon Treaty (PST), the Columbia River Fish Management Plan (CRFMP), the Endangered Species Act, management agreements negotiated between the parties to *U.S. v Oregon*, and state fishery regulatory processes. The ESA was discussed in Section II.B; other significant treaties and agreements are described below.

Pacific Salmon Commission

Management of Pacific salmon has long been a matter of common concern to the United States and Canada. After many years of negotiation, the Pacific Salmon Treaty was signed in 1985. The PST set long-term goals for salmon management for both countries and is advisory in nature. The principal goals of the treaty are to enable both countries, through better conservation and enhancement, to increase production of salmon and ensure that the benefits resulting from each country's efforts accrue to that country.

Pacific Fisheries Management Council

The Pacific Fishery Management Council (PFMC) is one of eight regional fishery management councils established by the Magnuson-Stevens Fishery Conservation and Management Act of 1976. The PFMC is responsible for all ocean fisheries off the coasts of California, Oregon, and Washington; Chinook and coho salmon are the main salmon species managed through PFMC's Salmon Fishery Management Plan.

The plan sets annual spawner escapement goals for the major salmon stocks and allocates harvest among commercial, recreational, and tribal users in ocean, estuarine, and inland fisheries. PFMC also uses season length, quotas, bag limits, and gear restrictions to achieve fishery management goals.

Columbia River Compact

The Columbia River Compact, ratified by Congress in 1918, established concurrent jurisdiction by the states of Oregon and Washington over Columbia River fisheries. The responsible entities are the Washington Department of Fish and Wildlife (WDFW) Commission and the Oregon Fish and Wildlife Commission (OFWC). The Compact sets harvest seasons and regulations for treaty and non-treaty harvest within the Columbia River.

U.S. v Oregon

The U.S. District Court ruled in 1968 that, under existing treaties, Columbia River treaty Indians were entitled to an equitable share of upper Columbia River fish returns. Later court rulings interpreted the tribes' equitable share to represent half the U.S. harvest of upper Columbia River salmon. After 20 years of legal tests and negotiations, a ten-year Columbia River Fish Management Plan was adopted by District Court order in 1988. Parties to the agreement were the United States; the states of Oregon, Washington, and Idaho; and the four treaty Indian tribes (Yakama, Warm Springs, Umatilla, and Nez Perce). The purpose of the CRFMP as defined by the court was to

> ". . . provide a framework within which the Parties may exercise their sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-Indian fisheries. In order to achieve the goals of the CRFMP, the Parties intend to use habitat protection authorities, enhancement efforts, artificial production techniques, and harvest management to ensure that Columbia River fish runs continue to provide a broad range of benefits in perpetuity."

Fisheries

Lower Columbia River salmonids are harvested in commercial and sport fisheries along the West Coast of the United States and Canada. Fisheries managers have divided these fisheries into the following: Canada/Alaska Pacific Ocean, Washington/Oregon/California Pacific Ocean, Lower Columbia River commercial harvest, Lower Columbia River recreational harvest, Columbia River Treaty Indian tribal fisheries, and tributary fisheries.

Canada/Alaska Pacific Ocean

Many fisheries in Canada and Southeast Alaska harvest far-north migrating Chinook stocks from the lower Columbia River Basin. Some Columbia River coho salmon are also harvested in Canadian fisheries. Canadian marine fisheries include commercial troll and net fisheries as well as recreational sport fisheries in northern British Columbia, Central British Columbia, West Coast of Vancouver Island, Strait of Georgia, and Strait of Juan de Fuca. In southeast Alaska, US/Canada Treaty Chinook marine fisheries include commercial troll and net fisheries as well as recreational sport fisheries. In recent years, Chinook harvest in terminal fisheries and harvest of Alaska hatchery production have increased, although these harvests are not subject to PST limitations.

Washington/Oregon/California Pacific Ocean

Numerous treaty Indian and non-Indian commercial troll and recreational marine fisheries exist along the West Coast. The U.S. Pacific Ocean fisheries are managed by the Pacific Fishery Management Council. Annual regulations recommended by the PFMC are reviewed and signed into law by the Secretary of Commerce.

Lower Columbia River Commercial

Lower Columbia River non-Indian commercial fisheries occur below Bonneville Dam in the mainstem (statistical Zones 1-5) or in select off-channel fishing areas (Figure II-3) In 1957, joint action by Oregon and Washington closed Zone 6 (Bonneville Dam to McNary Dam) to non-Indian commercial fishing.

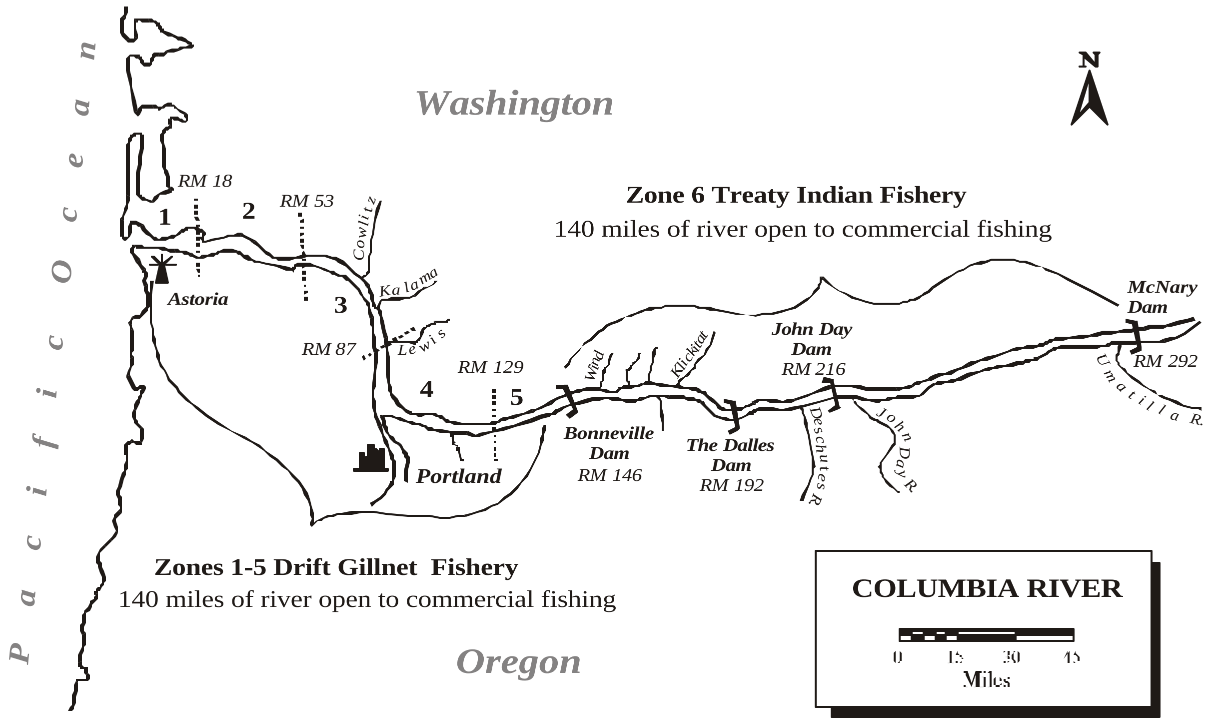


Figure II-3: Statistical Zones in the Columbia River (RM=River Mile)

The number of seasons and fishing days allowed for the commercial mainstem fishery has declined dramatically since 1938. Initially, fishing seasons were closed only in March and April and from August 25 to September 10. There has been no non-Indian summer fishing season since 1964 and negligible spring harvests since 1977. Before 1943, over 270 fishing days were allowed annually; since 1977, the total number of annual fishing days allowed on average was 38, and in the 1990s, 29 average annual fishing days were allowed. In the late 1950s, non-Indian commercial harvest comprised almost 100 percent of the Columbia River commercial fisheries landings; the percentage steadily declined to about 25 percent in 1995 and increased back to about 50 percent in 1999.

Lower Columbia River Recreational

Before 1975, recreational fisheries in the lower Columbia mainstem primarily focused on salmon and steelhead. From 1975 to 1983, fishery closures for spring Chinook and summer steelhead severely reduced salmonid angling opportunities. From 1984 to 1993, improved upriver summer steelhead, upriver fall Chinook, and lower river spring Chinook runs provided increased angling opportunities. However, poor returns in the mid- to late 1990s again limited recreational salmon fishing opportunities. Since 2001, improved spring Chinook runs and selective fishery implementation have increased angler effort by approximately 100,000 trips, for a total of about 250,000 angler trips per year. Lower Columbia sturgeon angler effort has ranged from approximately 140,000 to 200,000 trips per year since 1986.

Columbia River Treaty Indian

Treaty Indian harvest includes commercial, ceremonial, and subsistence fisheries. As stated above, treaty Indian tribes can harvest up to half the total harvest of upper Columbia River fish. The four treaty Indian tribes maintain a set net fishery above Bonneville Dam (statistical Zone 6). The tribal ceremonial and subsistence fisheries are of highest priority and generally occur before tribal commercial fishing. The Columbia River treaty tribes regulate treaty Indian ceremonial and subsistence fisheries in Zone 6.

Despite the treaties and the *U.S. v Oregon* decision, tribal harvest opportunity in the Columbia River has remained low due to conservation concerns for targeted fish. Since 1968, when management began under the *U.S. v Oregon* decision, tribal fishing opportunity peaked at 120 days in 1976, but has averaged about 60 days since 1990 (WDFW-ODFW 2002). The tribal commercial fishery targets fall Chinook, while spring Chinook are the main focus of the ceremonial and subsistence fishery. In 2003, increased returns allowed opening of the first tribal summer Chinook fishery since 1973.

Impacts of Hatcheries on Fisheries

The Columbia River hatchery system was initiated in the late 19th century to support commercial harvest (Section II.A). However, through the 1950s, wild fish remained the primary harvest target. The 1960s saw a rapid expansion of the hatchery system due to improvements in hatchery technology and declines in fish abundance. During much of the latter part of the 20th century, Columbia River hatchery programs supported intense commercial and sport fisheries in the ocean and in the river.

Although hatcheries can probably be credited with allowing continuation of commercial fisheries despite widespread habitat loss in the Columbia River, the resulting harvest pressures added to the declines in wild fish abundance (Lichatowich 1999). Hatchery fish stocks, because of their high juvenile survival and large biological capacity, can be harvested at rates far beyond what is sustainable by natural stocks. The increased abundance resulting from the expansion of the hatchery system in the 1960s encouraged extremely high harvest rates (Figures II-4 and II-5).

Until recently, wild and hatchery fish were intermingled and not differentiated in mixed stock ocean and river fisheries. As a result, wild populations were subjected to the same high harvest rates as hatchery fish, resulting in further declines in natural populations (Brannon et al. 1999). For example, coho production from Columbia River hatcheries expanded rapidly in the late 1950s, continuing to about 1970. In response to the increased abundance, harvest in the ocean and in the Columbia River commercial fisheries also expanded. As a consequence, exploitation rates on Columbia River coho exceeded 90 percent during the 1970s and there were years between 1970 and 1983 when harvest rates allowed only 10 percent to 20 percent of adult coho to escape the fisheries (Cramer, Maule, and Chapman 1991). The result, along with the loss of habitat, was the near extirpation of wild coho in the lower Columbia River (Johnson et al. 1991).

In recent years, declines in natural populations (leading, in some cases, to populations being listed as threatened or endangered under the Endangered Species Act) have resulted in sharp curtailment of harvest. These concerns have prompted fishery managers to develop techniques to separate harvest impacts on hatchery and natural populations. Techniques include clipping the adipose fin of hatchery fish in the Columbia River. This allows the release of harvested non-clipped wild fish. In addition, time and area restrictions have been instituted to allow targeting hatchery rather than wild fish. The result is that recent exploitation rates on wild fish have been reduced while allowing harvest of hatchery stocks.

Fisheries and hatcheries can also alter fish behavior and morphology. Fisheries may be selective for a particular timing or segment of the run, depending on management practices. For example, a fishery may disproportionately harvest the early portion of a run because of market- or industry-driven needs. Because run timing is heritable, the fishery removes this early run timing trait from the population. Over time, the effect is an altered run timing of the population. In the Columbia River, hatchery coho-targeted fisheries, in conjunction with hatchery practices, have altered run timing of lower Columbia River coho (Cramer and Cramer 1994). Hatchery coho brood stock is often obtained from the early part of the run, which generally results in early run timing for hatchery adults. Effort in fisheries targeting hatchery fish is concentrated during the time of hatchery fish abundance. Consequently, harvest of wild fish with the early run trait also occurs, thereby reducing this early run trait from the spawning population and altering run timing of the wild stock.

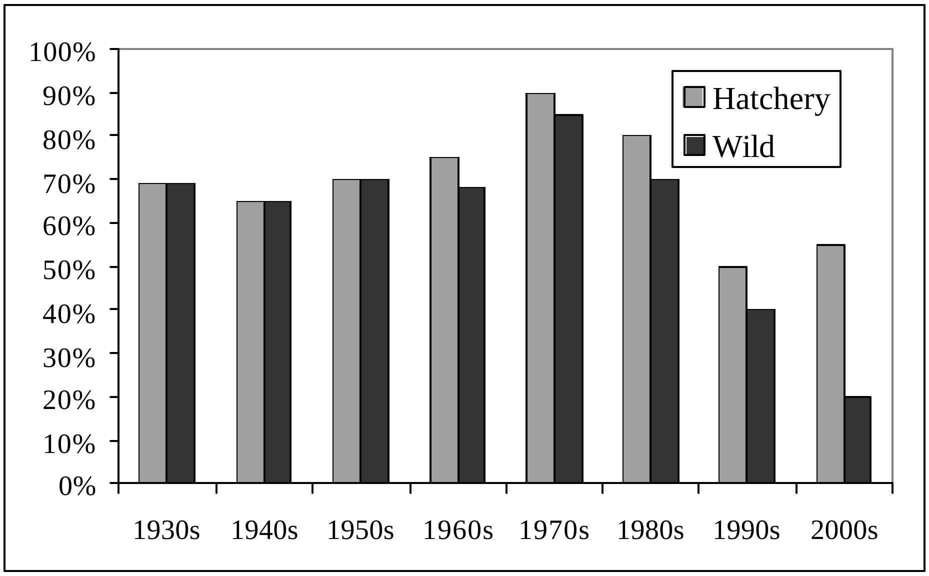


Figure II-4: Coho fishery exploitation rates

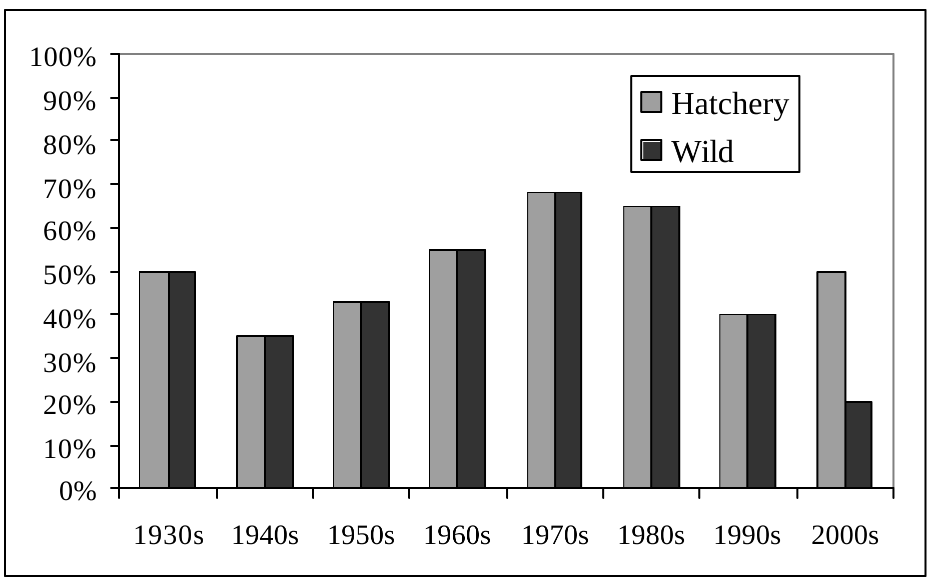


Figure II-5: Spring Chinook Fishery exploitation rates

II.E Regulatory Context for Artificial Production

Council Guidance

The Northwest Power and Conservation Council's Columbia River Basin Fish and Wildlife Program addresses fish and wildlife aspects of hydroelectric system operation, artificial production, restoration of habitat, and acquisition and protection of habitat for fish and wildlife (Section I.A). As a result of the Council's program, BPA has funded significant hatchery programs at several locations throughout the Columbia River Basin.

Several versions of the fish and wildlife program have been developed since 1981 and reflect an evolution of thinking about hatcheries in the Columbia River Basin. The earliest versions of the Council's program were aimed at construction of hatcheries primarily to support commercial harvest by treaty Indian fishers. By this time, the region had moved away from large facilities that segregated the hatchery from the wild populations toward more integrated programs (Section II.A). Subsequent versions of the Council's program show the development of supplementation (integrated programs), use of artificial production to conserve depleted natural populations, and an increasing focus on restoration of aquatic habitat.

The latest edition of the Council's Fish and Wildlife Program (Northwest Power Planning Council 2000) is a departure from the previous programs and reflects the region's concerns about declining wild fish populations, negative effects on habitats, and obligations to restore fish populations listed under the Endangered Species Act. The 2000 Program lays out a comprehensive, ecologically based framework for fish and wildlife restoration and management. Development of specific measures is left to subbasin planning. The Council's framework includes an overall vision for the program as well as generalized biological objectives. It also describes the Council's assumptions, guidelines, and policies for restoration strategies including the use of artificial production.

<u>Artificial Production in the 2000 Fish and Wildlife Program</u>

The Council's 2000 Fish and Wildlife Program moves away from large segregated production hatcheries toward integration of artificial production and habitat restoration. For example, a planning assumption set by the Council states:

> "This is a habitat-based program, rebuilding healthy, naturally producing fish and wildlife populations by protecting, mitigating and restoring habitat and the biological systems within them, including anadromous fish and migration corridors. *Artificial production and other non-natural interventions should be consistent with the central effort to protect and restore habitat and avoid adverse impacts to native fish and wildlife species*." (emphasis added)

In this, the Council firmly placed artificial production into the context of functioning ecosystems and productive habitat. The program also provided ecologically based scientific principles to guide the use of recovery strategies including artificial production. As regional policy guiding major funding and operation of hatcheries in the Columbia River Basin, these principles represent a significant departure from past policies where artificial production was used in an attempt to replace natural habitat and ecosystems. The Council did, however, recognize that, where habitat has been permanently eliminated (for example, as a result of construction of dams without adult fish passage), artificial production may be the best alternative to replace lost capacity and productivity.

The Council's program also acknowledges the experimental nature of hatcheries and the need for continuing research and evaluation. The experimental aspect of hatcheries is seen in the context of an adaptive management strategy that recognizes that scientific knowledge regarding artificial production and ecosystem functions will continue to be refined while the societal role of hatcheries within the context of natural resource management will continue to evolve. The program calls for each hatchery to develop a plan describing its purpose, method of operation, and its relationship to the vision, biological objectives, and strategies of the appropriate subbasin plan.

Specific strategies for the use of artificial production are to be developed locally as part of subbasin plans. However, the Council does provide significant guidance reflecting its policy of using hatcheries in conjunction with development of functional habitat. In Table II-2, the Council links the use of artificial production to the condition of the habitat, its potential for restoration, and the biological potential of the target species.

Criteria			Examples of Strategies	
Habitat Condition	**Description**	**Biological potential of target species**	**Habitat strategy**	**Possible artificial production strategy**
Intact	Ecological functions and habitat structure largely intact	High	Preserve	No artificial production
		Low	Preserve	Limited supplementation
Restorable	Potentially restorable to intact status through conventional approaches	High	Restore to intact	Interim supplementation
		Low	Restore to intact	Limited supplementation
Compromised	Ecological functions or habitat structure substantially diminished	High	Moderate restore	Limited supplementation
		Low	Moderate restore	Supplementation
Eliminated	Habitat fundamentally altered or blocked without feasible recovery option	High	Substitute	Replacement hatchery
		Low	Substitute	Replacement hatchery

Table II-2: Relationship between habitat condition and artificial production strategies specified in the Council's 2000 Fish and Wildlife Program.

The Council recommends against use of artificial production in cases where habitat is largely intact and the species has a high biological potential. These areas are to remain as refuges for wild production. As the condition of the habitat declines, the use of supplementation (integrated hatchery programs) increases, although it always remains within the context of habitat restoration. Finally, in instances where habitat has been completely eliminated, a hatchery could be proposed to partially mitigate for lost habitat. In keeping with other principles and goals in the Council's program, however, the replacement hatchery would have to operate quite differently from past hatcheries and must ensure minimal impacts on natural populations or other resource goals.

NOAA Fisheries Guidance

In 1990, as a result of widespread declines in the abundance of Pacific salmon and steelhead, NOAA Fisheries began a status review of all West Coast salmon and steelhead populations pursuant to the Endangered Species Act. NOAA Fisheries identified 52 Evolutionarily Significant Units along the West Coast. Of the 52 ESUs, 26 were subsequently listed as threatened or endangered. The Columbia River Basin contains 12 of the listed ESUs.

Pursuant to the ESA, NOAA Fisheries regulates federal and non-federal actions that might incidentally or directly take listed salmon and steelhead. Fish hatchery programs have been identified as actions that might incidentally take listed species or require direct take of listed species. NOAA Fisheries, in conducting its regulatory responsibilities, has described the potential risks and benefits of hatchery programs that should be considered relative to the species conservation goals of the ESA (Hard et al. 1992).

NOAA Fisheries must analyze the effects of a hatchery's propagation actions (facility operations, adult fish collection, juvenile fish releases and related monitoring and evaluation activities) to determine whether listed fish might be taken and whether the continued existence of listed fish is jeopardized. The steps in this analysis are described in the Endangered Species Act Consultation Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

If a hatchery propagates non-listed fish that do not subsequently affect listed species, no regulatory authorization from NOAA Fisheries is necessary. If hatchery operations do affect listed species and an incidental take is possible, the operations must be assessed and authorized via an ESA Section 7 consultation for federal facilities or an ESA Section 10 Incidental Take Permit for non-federal facilities. Any hatchery program that propagates a listed species must be authorized through a Section 10 Scientific Research/Enhancement Permit. These regulatory processes require the hatchery program manager to submit a biological assessment or permit application that fully describes the program's action and likely effects.

Recently, NOAA Fisheries adopted the 4(d) Rule (NOAA 2000a) which provides an alternative means (other than Section 7 or 10) for authorizing hatchery operations affecting threatened species. The 4(d) Rule, however, applies only to 14 ESUs of listed salmon and steelhead of which seven are located in the Columbia River Basin. The rule provides needed protections for threatened salmon and steelhead while loosening take prohibitions for approved hatchery programs and providing them with ESA regulatory approval. NOAA Fisheries can also authorize a hatchery program by approving a Hatchery and Genetics Management Plan submitted by the program manager. The advantages of the HGMP approach are long-term management planning, more public involvement, and less government paperwork.

The 4(d) Rule specifies that HGMPs must, among other things:

- have clearly stated goals, performance objectives, and performance indicators against which the program's success or failure can be measured
- provide as the primary purpose the conservation of that species
- account for the program's genetic and ecological effects on natural populations
- describe relationships between artificial propagation and harvest management
- include measures to avoid hatchery-influenced selection or domestication
- include monitoring and evaluation on program benefits and risks
- provide for adaptive management based on evaluations
- be consistent with plans and conditions established for tribal harvest allocations

The 4(d) Rule also includes a limitation on the take prohibition to accommodate a resource management plan developed jointly by the states and tribes under the jurisdiction of *U.S v. Oregon*. Such a joint plan could include harvest management and artificial propagation actions. In approving a joint plan developed under the framework of *U.S. v. Oregon*, NOAA Fisheries must determine that the plan would not appreciably reduce the likelihood of survival and recovery of threatened salmon and steelhead. In making such a determination, NOAA Fisheries must take public comment on how any HGMP included in the joint plan addresses the above criteria.

Simultaneously with adoption of the 4(d) Rule, NOAA Fisheries adopted a separate Tribal 4(d) Rule that limits take prohibitions for tribal resource management plans that do not appreciably reduce the likelihood of survival and recovery of threatened salmon and steelhead (NOAA 2000b). These tribal plans can also include hatchery programs.

The HGMP is now used in consideration of artificial propagation programs by NOAA Fisheries regardless of the approval mechanism, i.e. sections 7, 10, or 4(d). NOAA Fisheries' approval of an HGMP constitutes compliance with the substantive requirements of the ESA. The template for an HGMP can be viewed on NOAA Fisheries' web page at www.nwr.noaa.gov/1hgmp/hgmptmpl.htm.

With respect to artificial propagation programs, NOAA Fisheries' ESA regulatory authorities have objectives similar to those of the Northwest Power and Conservation Council's Columbia River Basin Fish and Wildlife Program, i.e. to increase the social benefits of artificial propagation programs while minimizing risks to naturally spawning populations. The HGMP template was developed in concert with Council efforts to improve the cost-effectiveness of hatchery programs and improve long-term fisheries planning in subbasins throughout the Columbia River Basin. NOAA Fisheries and the Council were looking for a single informational template that would efficiently satisfy both ESA regulatory and Fish and Wildlife Program processes for hatchery review and reform.

II.F Biological Context

Environmental context

Hatcheries culture salmonids for only a portion of their freshwater existence; thus, the success of hatchery programs is ultimately determined by conditions in the freshwater and marine environments. This insight is a surprisingly recent contribution to the conceptual foundation for artificial production (Independent Scientific Group 2000). Prior to the 1970s (Section II.A), hatcheries were viewed as separate from the natural ecosystem and somehow immune to the natural ecological principles and cycles of productivity that govern the natural world. However, the continued declines in salmon populations despite massive infusions of juvenile fish from hatchery programs led to a re-examination of the precepts of artificial production and a more ecologically grounded conceptual foundation that is increasingly characterizing the third historical phase of artificial production (Section II.A) (Independent Scientific Group 2000).

Part of the current conceptual foundation is the recognition of the role of environmental change and cycles in determining the abundance of salmon in both the short and long term (Lawson 1993, Hare and Francis 1995). Ocean, freshwater, and terrestrial environments apparently fluctuate significantly over 10 year or longer time periods (Hare and Francis 1995) and global climate change may result in fundamental shifts in environmental conditions. Although almost all management focus is on their freshwater life stages, salmon are a predominantly marine species. The success of any restoration action in freshwater, especially when viewed over short time periods, is strongly affected by ocean conditions. Actions may appear beneficial if taken during periods of favorable ocean conditions while beneficial actions may be viewed as having little, or even a negative effect, if evaluated during periods of poor ocean conditions. The apparent success of hatchery programs during the 1960s which led to a massive expansion of programs was in part due to its coincidence with favorable ocean conditions (Pearcy 1992). Likewise the collapse of these same programs in the 1970s was marked by a reversal of ocean conditions leading to poor returns from hatchery and wild populations alike (Pearcy 1992). The impact of climate change resulting from human or natural causes is likely to have fundamental impacts on salmon populations (Mote et al. 1999) and should be considered in the use and operation of artificial production.

Ecological context

Any discussion of ecological considerations regarding artificial production must address how the presence of hatchery fish (juveniles and adults) in the environment affect the performance and abundance of other species and wild fish of the same species. Because of the anadromous life history of many salmonids, the environment encompasses an immense area including freshwater streams, rivers, estuaries, and vast areas of the Northeast Pacific Ocean. The following brief summary of the ecological effects of artificial production describes the interaction of hatchery fish with wild fish of the same species (intra-species effects), with other species of fish including non-salmonids (inter-species effects), and the effects of those interactions on the environment and fish habitat.

Many traits, such as behavior, morphology, and physiology, of salmon can be shaped by the rearing environment. Traditional hatchery practices (where fish are maintained at high densities in flow-through tanks with ample food) show little resemblance to the natural rearing environment. In fact, by design, traditional hatcheries deliberately remove most of the complexity and "dangers" of the natural environment to increase efficiency and maximize the survival rate. Hatcheries represent unique environments with regard to feeding regimes, density, substrate, exposure to predators, and interactions with other fish. These differences can have substantial impacts on the resulting traits of hatchery fish (reviewed in Einum and Fleming 2001) with the potential for ecological impacts when they are released into the natural environment.

Intra-species effects

Individuals within a species group, e.g. a population, can affect each other and change the overall performance of the group. For hatchery and wild components of salmonid populations, intra-species effects include competition and disease. *Competition* is defined as negative interactions within a species over limited resources (Pianka 1994). Competition for limited resources results in a density-dependent survival rate and determines the ability of a particular location to support fish of a certain species and life stage (Hayes, Ferreri, and Taylor 1996, Bohlin et al. 2002). Competition between hatchery and natural fish has been frequently cited to explain declines in natural populations (Fresh 1997, Flagg et al. 2000). In small streams, competition for space or territory, including access to food and cover, is often a limiting factor (Chapman 1966). In the marine environment, food is considered the most limiting factor (Fresh 1997). Because capacity fluctuates in response to changes in the quality and quantity of habitat, the effect of competition, including competition between wild and hatchery fish, is not constant, but varies as a result of environmental changes.

Release of large numbers of hatchery fish into streams has been shown to have a negative impact on survival of wild fish (Fresh 1997). Simply through the process of density-dependent competition for limited resources, the increase in abundance caused by the infusion of fish from a hatchery will decrease the survival of the natural component (Bohlin et al. 2002). Hatchery fish, because they are raised in a benign hatchery environment with ample food resources, are often larger relative to their wild counterparts at the same age. When released into a stream with naturally produced fish, the larger hatchery fish can displace wild fish from their territories and decrease survival of the natural component (Rhodes and Quinn 1998). Hatchery fish can also be more aggressive than wild fish and disrupt normal foraging behavior (Fresh 1997).

Many hatcheries release fish at the smolt stage when active downstream migration occurs. Under these circumstances, competition may be minimal in streams, but may shift to later life stages in the estuary and ocean. An estuary, particularly the Columbia River estuary, represents a relatively limited area through which all fish, of all species, both hatchery and wild, must pass. Different salmonid species spend different periods of time in the estuary with juvenile chum and Chinook salmon spending the most time and apparently being the most dependent on estuarine conditions (Pearcy 1992). To safely pass through the estuary, wild salmonids have evolved a variety of strategies involving differences in size, timing, and behavior (Reimers 1973). Hatcheries, on the other hand, can release large numbers of juvenile fish into streams over a relatively short time frame and focus production into a smaller estuarine window (Bisbal and McConnaha 1998). To the extent that the diet and habitat preferences of hatchery and wild fish overlap, this may negatively impact the survival of both (Bisbal and McConnaha 1998, Flagg et al. 2000). In the ocean, density dependent competition between hatchery and wild fish can decrease survival and growth of wild salmonids particularly during periods of reduced upwelling and ocean productivity (Mote et al. 1999). The success of hatchery programs can be high during periods of high upwelling and ocean productivity but quite low when conditions in the ocean decline (Pearcy 1992, Levin, Zabel, and Williams 2001). The mechanisms leading to decline in success during periods of low ocean upwelling are not entirely known, but appear to be related to increased competition for decreased food supplies as well as increased predation (Mote et al. 1999).

Transmission of disease between hatchery and wild components of the same species is known to occur, although neither the transmission nor the potential negative effects of transmission are consistent or well demonstrated (National Research Council 1996). Most pathogenic microorganisms present in hatchery fish existed in wild fish populations and were introduced into hatcheries (Flagg et al. 2000), although hatcheries have been known to introduce new diseases and parasites into the natural environment with devastating results (Johnsen and Jensen 1991). Hatchery fish are reared at higher densities than fish in the wild, so naturally occurring diseases can be propagated and spread within hatchery populations. When these fish are released into the wild, active disease agents can lead to infection of the entire population. However, the clear line of evidence linking hatchery disease incidence with the incidence of disease in and overall survival of natural populations is often lacking (National Research Council 1996). Instead, based on knowledge of disease transmission within other species and documented examples of transmission between hatchery and natural populations (Johnsen and Jensen 1991), the inference is made that disease transmission between hatchery and wild populations can occur and should be minimized. To this end, hatchery managers have developed strict protocols for disease control in hatcheries and for the release and transfer of diseased fish from hatcheries (Flagg et al. 2000).

Inter-species effects

Interactions between hatchery fish of one species and natural or hatchery fish of another species can be classed as *competition* when both species compete for similar resources and *predation* when one species actively preys on the other. Competition and predation also occur within a species; many of the concepts discussed here can apply to both inter- and intra-specific interactions. In theory, organisms evolve to minimize competition between species through differences in food, space, or time requirements (Pianka 1994). Nonetheless, some competition does occur between closely related species whose life stages overlap in time and space (Pianka 1994), as is true for many salmonids (Fausch 1988). For example, juvenile steelhead in small streams will occupy a range of habitats, whereas pools are the habitat of choice for juvenile Chinook salmon. When the two species overlap, steelhead may be pushed out of the pools by competition with Chinook (Everest and Chapman 1972). Artificially increasing the number of one species of fish through introduction of hatchery fish of various life stages could disrupt competitive balances between species. Competition could be increased when hatchery fish are introduced into the natural environment (Levin and Williams 2002). Hatchery fish often arrive in a stream with markedly different behavior from their natural counterparts (Flagg et al. 2000) and might not know the "rules" or signals used between and within species to define territories and minimize competition.

Flagg et al. (2000) describe three ways in which the presence of hatchery fish can affect predation. The first is the direct predation of hatchery fish of one species on wild fish of another. They conclude that direct predation can occur, although reported rates are generally low. For example, studies cited in Flagg et al. (2000) report predation rates by hatchery steelhead and Chinook on natural components of either species ranging from 0 to 22 percent in Columbia River tributaries.

The second type of hatchery effect on predation suggested by Flagg et al. (2000) involves the effect of large numbers and concentrations of hatchery fish on predator behavior and the resulting effect on survival of other salmon species and on natural components of the same species. Hatchery releases can attract predators such as Northern pikeminnow to hatchery release sites. Predators can rapidly shift their behavior to exploit abundant hatchery fish (Collins, Beatty, and Crain 1995). Flagg et al. (2000) note that such behavior could have negative impacts on fish of the same or other species if the hatchery fish are released on top of natural fish, or a positive effect if it serves to divert predators away from areas where other fish are abundant. It has been suggested that the release of large numbers of hatchery fish could satiate predators and buffer the effect of predation (Flagg et al. 2000). On the other hand, Beamsderfer and Rieman (1991) suggest that an increase in the prey base caused by the continual release of large numbers of hatchery fish could lead to an increase in the predator population. In the end, while it seems likely that an influx of large numbers of hatchery juvenile salmonids can affect predator behavior and abundance, evidence for an overall positive or negative effect is inconclusive (Flagg et al. 2000).

The third way in which hatcheries can affect predation is through the effect of hatchery practices on the vulnerability of hatchery fish to predation (Flagg et al. 2000). As a result of their protected environment, hatchery fish appear to be naïve regarding predators (including other fish species and birds) and lack the behavior and morphology developed by fish in natural environments to avoid predation. Post-release survival of hatchery fish has been shown to increase if they are first “trained” or conditioned to recognize and avoid predators. Also, hatchery fish are often lighter in color than wild fish and stand out against the dark substrate of most streams, making them more vulnerable to predators such as mergansers and other birds. Raising fish over a darker or mottled substrate in hatcheries leads to hatchery fish with more natural coloration, reducing their vulnerability to predation in the natural world. Flagg et al. (2000) also cite instances where release strategies (time of day, volitional versus forced releases, etc.) made the released fish less attractive to predators.

<u>Hatchery fish and the environment</u>

Salmonids, particularly anadromous salmonids, are key components of stream and river ecosystems in the Pacific Northwest (Willson and Halupka 1995). Because the adults of most anadromous salmonid species die soon after spawning, salmon and steelhead link marine, freshwater and terrestrial environments (Schindler et al. 2003). Most of the body mass of adult anadromous salmonids is acquired during their marine residence. When adults return to spawn and die, these nutrients are made available to the freshwater environment enhancing stream productivity and the survival of subsequent generations of salmon (Cederholm et al. 1999). Because bears, birds, and other terrestrial vertebrates consume the carcasses, salmon also contribute to terrestrial environments (Naiman et al. 2002). Salmon can also modify stream channel dynamics and substrate conditions by digging spawning nests (Schindler et al. 2003).

Hatcheries can have positive or negative impacts on the interaction between salmon and their environment. Integrated production programs may bolster populations and, because under such programs hatchery fish are expected to return and spawn naturally, may add to the number of carcasses in a stream, thus increasing the contribution to aquatic and terrestrial environments. On the other hand, in the segregated hatchery systems that characterize older or more conventional programs, hatchery fish return to the hatchery in a closed loop and their carcasses do not contribute to the natural environment. In these cases, the portion of the total abundance that otherwise would have contributed to the overall ecological health of aquatic and terrestrial systems is diverted to the hatchery where it may ultimately be discarded in a land fill (National Research Council 1996).

Genetic Aspects

Artificial production involves the controlled mating of fish and subsequent rearing of young in a regulated environment. As a result, artificial production, like all forms of animal husbandry, can have significant impacts on the genetic makeup of hatchery-bred fish. These genetic changes can negatively affect the fitness or biological performance of hatchery fish. In addition, because hatchery fish inevitably interact with naturally produced fish, the fitness of wild populations can be negatively affected, a particular concern with populations listed under the Endangered Species Act. While the following discussion dwells mainly on potential negative genetic aspects of hatcheries, it should be recognized that hatchery managers increasingly recognize the potential negative effects of husbandry practices and are developing techniques to minimize genetic impacts of hatchery production.

Genetic Effects of Hatchery Programs

Genetic differentiation of hatchery from wild fish can occur as a result of the stock choice and number and choice of fish used to start a hatchery (founder effect). Although there is extensive genetic differentiation among wild populations (reviewed in National Research Council 1996), a hatchery strain derived from a non-local river will be different from the system's wild fish because each salmon population evolves its own genetic traits due to local adaptation. Even when derived from the same river as a wild population, a hatchery population can differ due to founder effects resulting from the small number of broodstock fish used or broodstock fish being taken from only a segment of the wild population, e.g. a temporal or maturity component (Flagg et al. 2000).

Genetic changes that can occur due to domestication selection include 1) intentional selection by hatchery managers for traits at spawning; 2) non-random collection of broodstock from a spawning population, e.g. collection of early-run fish (Flagg et al. 2000); 3) unintentional selection in the hatchery due to the artificial conditions that affect survival, social behavior, and growth (Flagg et al. 2000); and 4) the release of fish from natural selection pressures that would have been imposed on them in the natural environment (Fleming and Gross 1989).

It may be possible to minimize, though not completely avoid, domestication selection by establishing more natural rearing conditions and applying more natural practices during rearing and at release. The Natural Rearing Enhancement System is one such effort.

Types of genetic effects resulting from artificial production

Concerns about the genetic effects of hatchery fish on wild populations fall into two broad categories: 1) direct genetic effects caused by hybridization and introgression, and 2) indirect genetic effects of altered natural selection regimes or reductions in population size.

***Direct Genetic Effects* –** Direct effects occur due to hybridization of hatchery fish with wild salmon and alteration of the wild gene pool through backcrossing of these hybrids (introgression) in subsequent generations. On a broad scale, crosses among fish from multiple populations will result in the loss of genetic uniqueness of each individual population (population identity). However, such genetic changes will only be important if the extent and nature of genetic variability is important for survival and reproduction (fitness) of wild populations. In this case, the mixing of distinct populations (wild and non-local hatchery strain) would reduce fitness in the combined population. While the degree of fitness loss seems to depend on the genetic differentiation between the parents, quantitative data are largely lacking on the frequency and severity of this problem (termed "outbreeding depression") in animals. Low amounts of gene flow can counter the inevitable loss of genetic variability in isolated populations, without overwhelming local forces of adaptation. Moderate to massive hatchery mixing of gene pools, however, is likely to impede or even overwhelm local forces of natural selection.

Fortunately, the potential importance of local adaptations has been increasingly accepted and the practice of using non-local fish in hatcheries has decreased. The potential for genetic impacts via straying of fish from large-scale hatcheries remain, particularly for small, vulnerable, non-target wild populations. Moreover, the establishment of locally based hatchery broodstock does not eliminate concerns about domestication selection and the introduction of hatchery traits into the supplemented wild population. The constant, year-after-year supplementation of wild populations with hatchery fish means that both domestication selection on the hatchery-reared component and natural selection on the wild-reared component will operate on the combined population. This will disrupt and/or impede local adaptation to the wild environment, and consequently, will reduce the ability of the population to respond to environmental change. Moreover, if the abundance of hatchery fish is greater than that of the wild fish, the population will evolve in response to domestication (hatchery) selection rather than natural selection. This would occur despite fish spawning in the wild and annual mixing of wild fish into the hatchery broodstock.

***Indirect Genetic Effects* –** Indirect genetic effects are the result of behavioral, e.g. predation by larger hatchery fish on smaller wild fish, ecological (density-dependent competition), and disease interactions with the wild population. These interactions may reduce the success of wild fish, thereby reducing the genetically effective population size of the wild population. This can erode genetic variability and increase the chances of inbreeding depression (as discussed above). Indirect genetic effects also include the risk of overharvest of less abundant (principally wild) populations in a mixed population fishery (Brannon et al. 1999) and shifts in predator abundance or behavior in response to the presence of large numbers of hatchery fish (reviewed in Waples et al. 1991, Flagg et al. 2000). Hatchery fish may affect different components of wild population, e.g. fish of a particular size, life history or geographic location within the wild population, and change the pattern of natural selection. For example, the early spawning time of hatchery fish could alter competition for mates and nest sites and affect the intensity of selection on the early breeding component of wild populations. The potential for competition among juveniles is also significant, since diet and habitat choice of hatchery fish are likely to overlap those of wild fish. Territorial and social dominance behavior in salmonids, as a result of interactions between species or between cultured and wild fish, can affect both mortality and growth (Fausch and White 1986, Fleming et al. 2000). The intensity and form of competition may be altered when salmon from populations that have not developed together interact with one another (Fausch 1988).

Chapter III. Methods

The Artificial Production Review and Evaluation examined 227 Columbia River salmon and trout hatchery programs to determine if current hatchery operations were consistent with harvest and conservation goals identified for each program. This chapter describes the APRE approach to data gathering, evaluation, and reporting/accountability. APRE resulted in the creation of a web-based system that allows information to be updated in the future. The web-based system currently produces two reports: the APRE benefit-risk profile and the HGMP for a selected hatchery program. The review and report should not be viewed in isolation, but rather as an on-going effort to reform hatcheries. It is envisioned that the web-based system will be expanded in the future through links to other existing datasets and that this expansion will lead to the development of other types of reports.

III.A Premises

The APRE approach was based on two premises for determining the success of a hatchery program. First, to be successful, a hatchery program must be *internally consistent* with its own stated purpose and *externally consistent* with the goals and priorities for the environment, including other potentially affected fish populations. For example, if the purpose of a hatchery program is to contribute to a particular harvest, its benefits were judged by its contribution to that fishery (internal consistency) and the degree to which it posed an acceptable level of potential risk to conservation, genetic, and other goals for nearby populations (external consistency).

The second premise of the APRE was that almost any human intervention to manipulate the environment poses some level of risk to the existing environment and species. There are few, if any, "no risk" strategies for fisheries restoration and management. Instead, different strategies present a variety of risks that must be evaluated by decision-makers in an informed manner. The APRE evaluated the risk associated with each hatchery program relative to its intended purpose and its potential impact on other goals.

A hatchery program was judged to be successful if it met the following conditions:

1. It must produce a healthy and viable hatchery population.
2. It must make a sustainable contribution of adult returns to conservation and/or harvest.
3. Its potential effects on wild and native populations and the environment must be understood.
4. It must collect, record, evaluate and disseminate information pertaining to conditions 1 – 3 so that decision makers may be informed about the benefits and risks of the program relative to other means for achieving similar conservation and harvest goals

Conditions 1 and 2 dealt with the potential <u>benefits</u> of a hatchery program. Conditions 3 and 4 dealt with the potential <u>risks</u>. Note that Condition 3 does not imply that a successful hatchery program will pose no risk; rather it calls for the risk to be clearly identified and accepted relative to the risk of alternative strategies to achieve resource goals. It is important to recognize that all strategies, including hatcheries, have potential benefits and risks. The potentially significant risks imposed by hatcheries must be compared to the risks of alternatives (including no action) and weighed through informed decision-making. The underlying working hypothesis must then be carefully monitored and evaluated within a framework of adaptive management. The determination of whether the benefits associated with a hatchery program outweigh the risks is a policy judgment that should take into account the relative benefits and risks associated with alternative strategies to meet the same or similar resource goals.

III.B Approach

The APRE was based on information collected from federal, state, and tribal hatchery managers and operators through a structured interview process. Interviews with fishery and hatchery managers used a questionnaire designed in consultation with a census and questionnaire expert to facilitate collection of unbiased responses from the managers. Managers were not required to document the basis for their responses to the APRE questions. At several points in the process, review opportunities were provided to the managers to ensure that the information accurately reflected their knowledge of the facilities and current operations. The potential benefits and risks of each program were evaluated by comparing the information provided by the managers to criteria developed from the Scientific Framework and Hatchery Review Program (HSRG 2002) prepared by the Hatchery Scientific Review Group and by the Council's Integrated Hatchery Oversight Team (IHOT 1995). The IHOT was established by the Council to conduct performance audits on all hatcheries in the Columbia River Basin. A set of hatchery review protocols and guidelines was developed by IHOT for that purpose. The results of the evaluation of all 227 artificial production programs identified in the Columbia River Basin are summarized in individual program reports maintained within a web-based system developed for the APRE. Managers were provided the opportunity to review and comment on the information and conclusions before the program reports were posted to the system.

The APRE process can be broken down into three general steps: information gathering, evaluation, and reporting/accountability.

Step 1. Information gathering

The first step was to gather information on currently identified fish stocks and existing hatchery programs. The fish stock list was compiled from information provided by the management agencies and included salmonid and non-salmonid species with natural and hatchery components (Chapter IV). The APRE process identified 260 hatchery and 245 natural fish populations throughout the U.S. portion of the Columbia River Basin. While the stock list includes several non-salmonid fish stocks, development of goals by the fishery managers has focused largely on salmonid stocks. Through a structured questionnaire termed "Form 1", managers were asked to describe the current status of each stock as well as short term (less than 15 years) and long term (more than 15 years) goals in regard to harvest (type and location) and conservation (biological significance, genetic viability, and habitat status).

Conservation status and goals for each salmonid stock were described by the fishery managers in terms of biological significance, genetic viability, and habitat status. Biological significance is a measure of the importance of the population to the long-term persistence of its ESU and is a function of its stock origin, the uniqueness of its biological attributes (life history, physiology, morphology, behavior, etc.), and metapopulation structure (number of spawning aggregations). *Genetic viability* is a measure of the ability of a population to survive over time in the natural environment as a function of effective population size, productivity (recruits per spawner), and composition of spawning population (natural vs. hatchery). *Habitat status* describes the ability of the environment to support the population over time as a function of quantity and quality of habitat available to the population.

Information on each hatchery program was also collected from the hatchery managers. Programmatic and operational information on each program was provided through the Form 2 questionnaire. Programmatic information described the nature, i.e. broodstock source, number released, life stage, and location, of the releases comprising the program. The HSRG framework that formed the basis for these questions is presented in Appendix A.

Operational information collected in Form 2 described the procedures and practices used to produce the fish in a hatchery program. This information was grouped into sections relating to 1) the health and viability of the hatchery population 2) the effect of the hatchery on natural populations and the environment, 3) the hatchery's contribution to harvest and conservation, and 4) the measures employed for accountability and monitoring of hatchery operations.

Information provided by the managers in Form 1 and Form 2 was compiled in a web-accessible database. Prior to the evaluation step, hatchery managers were able to review and refine information in the data set.

Step 2. Evaluation

The second step in the APRE process was to evaluate the responses provided by the managers relative to the criteria for hatchery success developed by the HSRG (2002). The information provided by the managers on stock goals (Form 1) and on hatchery program operations (Form 2) was evaluated against the HSRG guidelines to yield a set of statements describing benefits and risk (Figure III-1). Forms 1 and 2 are presented in appendices B and C.

The evaluation process determined if the current operations at each hatchery, as described by the managers, were consistent with the goals identified for the hatchery program

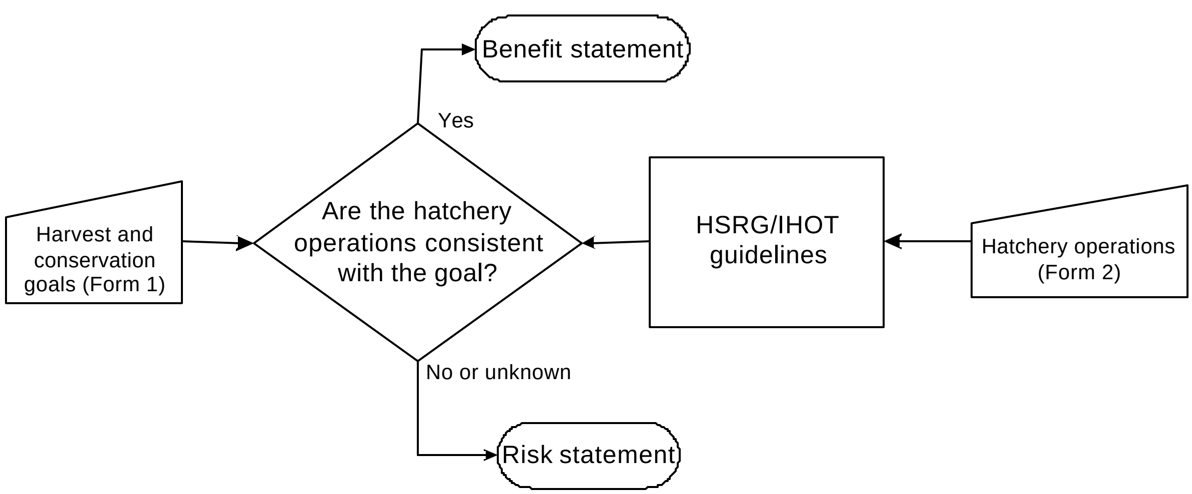


Figure III-1: APRE process for evaluation of information provided on harvest and conservation goals (Form 1) and hatchery operations (Form 2)

using the criteria established by HSRG/IHOT. The responses provided to the questions in Forms 1 and 2 were matched to criteria that were appropriate to the goal (harvest or conservation) and to the type of hatchery program (integrated or segregated). The result was a series of benefit and risk statements indicating areas where current operations are consistent with the goals based on the guidelines or where operations were inconsistent with the guidelines and could be improved.

Hatchery managers were asked to review the results of the evaluation prior to the results being posted on the APRE web system. This review provided another opportunity to refine the data and examine the preliminary results.

Step 3. Reporting and Accountability

An example of an APRE benefit and risk report for the Cowlitz spring Chinook hatchery program is shown on Table III-1. Additional excerpts from the APRE database are show in Appendix D; a summary of findings by province is presented in Appendix E. Each hatchery program report in the web-based APRE system contains similar tables. In addition to the evaluation shown in Table III-1, the hatchery program reports include programmatic information for each program as well as information on returns, harvest, and survival rates provided by the managers for each program.

In Table III-1, the columns are evaluation criteria for the target stock (Cowlitz spring Chinook) and for other stocks in the Cowlitz River. The rows are categories of hatchery practices. The cell contents, e.g. 2/0/0, are the number of evaluation criteria guidelines met for each hatchery practice category, the number that were not met, and the number of guidelines for which information is missing. Each number in a cell is hyperlinked to benefit and risk statements on the web site which explain the evaluation conclusions.

The upper left box marked "Harvest" under "Target Stock" shows the numbers **2/0/0**. This shows that for the harvest goal provided on Form 1 by the managers for the Cowlitz spring Chinook program, two guidelines were met (***2***/0/0), indicating a benefit. For choice of broodstock, all guidelines were met (no guidelines were not met) (2/***0***/0), indicating no risk, and no information on broodstock choice was missing (2/0/***0***), also indicating no risk. Under the Target Stock-Survival column and the Hatchery Practices-Release row, the effect of smolt release practices described for the Cowlitz spring Chinook program indicates that nine guidelines were met (a benefit) (***9***/7/1), but seven guidelines were not met (risks) (9/***7***/1), and information was not provided to address one guideline (a risk)(9/7/***1*****)**.

After the reports for each hatchery program were developed through the APRE web database, managers were able to review and comment on the reports prior to the reports being made available to the public. The individual program reports are intended as a resource for hatchery managers and subbasin planners. Because the reports contain many of the elements of the Hatchery and Genetics Management Plan (HGMP) required by the federal managers under the Endangered Species Act, the option is available within the APRE web site to reformat the results into a form that can serve as a draft HGMP. It is anticipated that the federal managers will work with the state and tribal hatchery managers to refine these drafts into final HGMPs for each hatchery program.

Hatchery Practices	Criteria for Successful Outcomes (Table entries are: Guidelines met / Guideslines NOT met / Insufficient Information)							
	Target Stock			Other Stocks			Environment (Fish passage, NPDES Discharge)	Implementation Monitoring
	Harvest	Biological Significance	Survival	Ecological Interactions	Genetic Interactions	Harvest Interactions		
Broodstock Choice	2 / 0 / 0	3 / 0 / 0	2 / 0 / 0	1 / 1 / 0	1 / 0 / 0	1 / 0 / 0		1 / 0 / 0
Broodstock Collection	11 / 1 / 0	4 / 0 / 0	15 / 1 / 0	7 / 0 / 0	5 / 0 / 0			11 / 1 / 0
Adult Holding	3 / 0 / 0		3 / 5 / 0				1 / 0 / 0	3 / 0 / 0
Spawning	5 / 0 / 0		6 / 1 / 0	1 / 0 / 0				
Incubation	13 / 3 / 0	0 / 3 / 0	20 / 4 / 0	2 / 1 / 0			0 / 1 / 0	10 / 2 / 0
Rearing	18 / 10 / 0	2 / 3 / 0	19 / 15 / 0	5 / 6 / 0			1 / 2 / 0	13 / 6 / 0
Release	9 / 8 / 1	2 / 3 / 1	9 / 7 / 1	5 / 6 / 1	3 / 2 / 0	4 / 1 / 0	2 / 0 / 0	8 / 7 / 1
Facilities	3 / 0 / 0		3 / 0 / 0				3 / 2 / 0	1 / 0 / 0
Effectiveness Monitoring	1 / 0 / 0	2 / 2 / 0	3 / 3 / 0					9 / 3 / 0

Table III-1: Example of APRE web-based evaluation report for a hatchery program (Cowlitz Spring Chinook)

Chapter IV. Results

The primary product from the APRE is the database which contains the responses from the fishery and hatchery managers for individual hatchery programs within the Columbia River Basin. The results presented in this chapter are a summary of the information contained in the database. The database, which is accessible through the APRE website at www.apre.info, contains reports for each of the hatchery programs reviewed as well as links to this Basin level report and the federal HGMP process.

The APRE database is intended to form the foundation for continuing consideration of artificial production in the Columbia River Basin. The individual program reports in the database contain a summary of facility information including operator, funding sources, and overall performance, as well as recommendations for each hatchery based on the HSRG and IHOT guidelines. In addition, the reports provide a basis for other regional review efforts including the Council's subbasin planning effort and development of federal HGMPs. The database, which hatchery managers and other interested persons are encouraged to use, is designed to be updated as hatchery reforms are enacted.

This chapter summarizes results of the APRE into the categories of fish stocks, hatchery operations, distribution of hatchery releases, hatchery goals and purposes, funding, and monitoring and evaluation.

IV.A Fish Stocks

Fishery managers identified a total of 505 fish stocks within the U.S. portion of the Columbia River Basin. Of these 505 stocks, 260 were identified as hatchery programs; and 227 of these programs were reviewed within the APRE (Table IV-1) while 33 were not reviewed because of inadequate information. The numbers of hatchery programs reviewed within the APRE are shown on Table IV-1 in parentheses.

	Salmonids		**Other Species**	**Total**
	Anadromous	*Resident*		
Natural Stocks	89	99	57	**245**
Integrated Stocks	102 (102)	10 (9)	3 (2)	**115 (113)**
Segregated Hatchery Stocks	73 (73)	55 (36)	17 (5)	**145 (114)**
Total	**264**	**164**	**77**	**505**

Table IV-1: Number and production origin for anadromous salmonids, resident salmonids, and non-salmonid fish stocks identified by fishery managers in the U.S. portion of the Columbia River Basin

It is important to note that there are no common criteria for defining stocks either within or between management agencies; stocks are simply groups of fish for which the managers have identified a management goal or interest. There are species, primarily non-salmonid species, for which stocks were not identified, whereas salmonid species usually were divided into many stocks with varying management goals. Identified stocks do not necessarily have a genetic basis; however anadromous salmonid stocks appear to be associated with identified genetic populations. Natural stocks are defined more broadly than hatchery stocks which are related to specific hatcheries and programs. Despite these inconsistencies, the distribution of stocks has some basis in the biological organization of fish populations within the Columbia River Basin and reveals a great deal about management agency emphasis.

Anadromous salmonid stocks accounted for 53 percent (264) of stocks identified by managers, 32 percent (164) were non-anadromous (resident) salmonid stocks, and 15 percent (77) were non-salmonid stocks. The majority of stocks were found in the Lower Columbia province which reflects the large number of hatchery programs in this province (Figure IV-1).

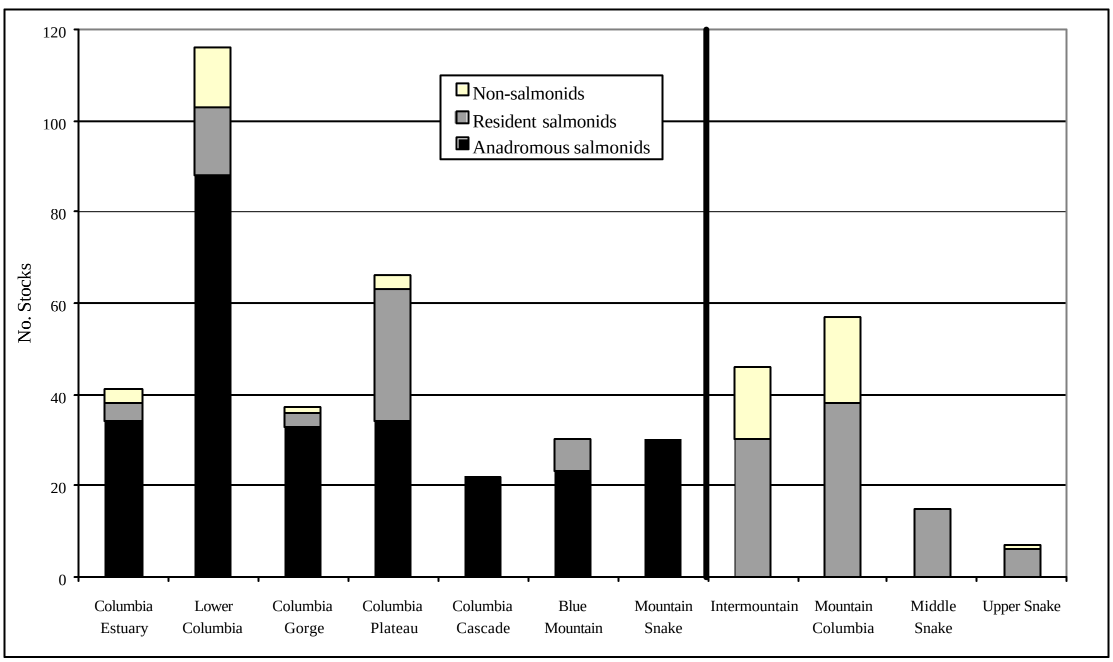


Figure IV-1: Distribution of fish stocks identified by fishery managers within the U.S. portion of the Columbia River Basin. Vertical line represents the limit to anadromous fish passage.

The smallest number of stocks are found in the Upper Snake province. There are no anadromous stocks above the blockages to anadromous passage at Hells Canyon Dam on the Snake River and Chief Joseph Dam on the Columbia River. However, resident salmonid stocks were identified both above and below the limit to anadromous fish passage. The greatest numbers of resident salmonid stocks were in the Intermountain and Mountain Columbia provinces. These provinces also had the greatest number of non-salmonid stocks in the Basin. Non-salmonid stocks represented a wide variety of fish species including non-native species such as crappie, bullheads, channel catfish, tiger muskie, and largemouth and smallmouth bass, as well as native species such as burbot, sturgeon and lamprey. Of the total number of stocks identified, 24 percent were part of populations that are listed under the Endangered Species Act. Of these listed stocks, 53 percent have a hatchery component.

Fish stocks identified by the managers represented both hatchery and natural production (Table IV-1). About half the stocks were natural fish. However, the majority of anadromous salmonid populations derived from hatchery programs. The Columbia Cascade province had the highest proportion of hatchery populations of anadromous fish and the Columbia Gorge the lowest. However, in the Columbia Cascade, the hatchery stocks represent several relatively small programs while in the Columbia Gorge, the hatchery stocks represent a few very large programs. The greatest number of natural populations was in the Lower Columbia province while the smallest number was in the Columbia Cascade province.

Except for the Middle Snake province, the majority of resident salmonid populations represented naturally spawning fish. The largest numbers of resident salmonid stocks were described for the Mountain Columbia (37) and Intermountain (31) provinces; most of these were natural populations. The fact that there were no resident salmonid stocks in the Columbia Cascade or Mountain Snake provinces does not mean that there are no resident salmonids in these areas or that they are of no management interest; it simply means that the managers did not identify any.

IV.B. Hatchery operations

Type of operation.

The stocks discussed above were placed by the managers into one of three production categories: (1) natural stocks, (2) integrated stocks, and (3) segregated hatchery stocks. A natural stock is intended to have minimal influence from artificial production and to survive through its own productivity and the capacity of the environment. Likewise, a segregated hatchery stock is intended to have minimal influence from and on surrounding wild stocks. This type of program minimizes interbreeding of hatchery fish with wild populations. Segregated programs typically release large numbers of juvenile fish.

An integrated hatchery program, in contrast, uses an open production cycle in which the hatchery population is combined with the wild population to form a single aggregate population. Controlled genetic exchange is encouraged between hatchery and the wild components of the population. The proportion of hatchery and wild spawners in either population component is limited to minimize genetic and behavioral divergence between hatchery and wild components. The intent of an integrated program is to minimize genetic drift within the combined population and to produce hatchery fish which are equivalent in fitness and behavior to the fish produced by natural spawners in the same system. The ideal integrated hatchery program contributes to the abundance of its naturally spawning counterpart without significantly altering the genetic or behavioral characteristics of the wild population.

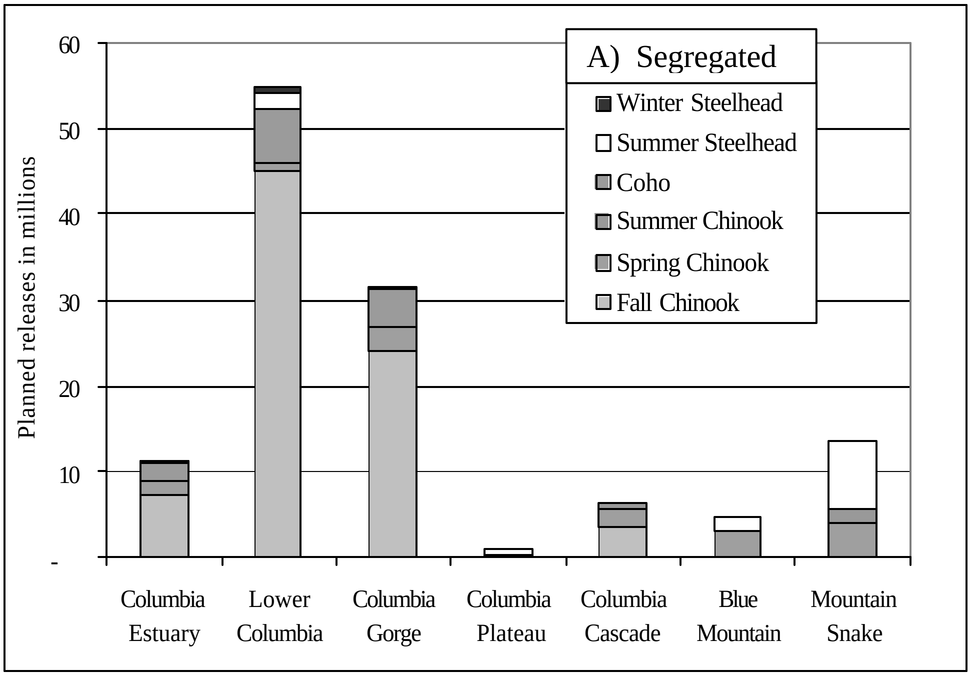
The results indicate that the majority of programs in the lower portion of the river (Estuary, Lower Columbia, and Columbia Gorge provinces) are segregated programs (Figure IV-2A), while a greater proportion of programs in the upper part of the Basin are integrated (Figure IV-2B). More than 95 percent of the programs in the Columbia Gorge are categorized as segregated. This is the result of a few very large, older facilities, such as Bonneville and Spring Creek hatcheries, which, like many programs in the lower river, release large numbers of fall Chinook and coho to supply lower river and ocean fisheries.

Because of the earlier practice of locating most mitigation hatcheries in the lower river (Section II.A), those in the upper river are usually the newest facilities constructed since the 1970s. Many of these programs were either designed as integrated programs or have been recently modified to operate under the new conservation approach aimed at rebuilding wild populations. Almost 95 percent of the programs in the Columbia Plateau, just upstream from the Columbia Gorge, are classified as integrated (Figure IV-2). Artificial production programs in the Columbia Plateau include those in the Yakima and Umatilla provinces which were developed with the intent of producing integrated hatchery/wild populations. Priest Rapids Hatchery is also an integrated program, combining hatchery fish with the large native fish population spawning in the Hanford Reach.

The differences in fish culture practices between and among provinces can be identified using the APRE information. For example, most fall Chinook in the Columbia River Basin are released from segregated programs at large production facilities in the Lower Columbia and Columbia Gorge provinces (Figure IV-2A). These facilities were, for the most part, constructed to support the ocean fishery off Oregon and Washington. Because fall Chinook migrate to the ocean as sub-yearlings (only a few months after emergence), they are relatively inexpensive and easy to rear in hatcheries in large numbers. Spring Chinook, on the other hand, migrate as yearlings and must be maintained in hatchery facilities for a full year prior to release. Most coho in the Columbia River Basin, like fall Chinook, are released from segregated programs in the lower river. Segregated programs also account for most summer steelhead in the Basin. The majority of steelhead programs are located in the Mountain Snake province of Idaho.

Most spring Chinook in the Columbia River Basin are released through integrated programs (Figure IV-2B). Integrated programs for spring Chinook are located throughout the Basin with the majority in the Lower Columbia, Columbia Plateau, and Mountain Snake provinces. Large numbers of coho are released from integrated programs in the Washington tributaries in the Lower Columbia province (Lewis, Cowlitz, Washougal rivers) and are expected to contribute to natural populations. Fall Chinook are released through integrated programs mainly in the Lower Columbia and Columbia

Plateau provinces. The fall Chinook released within the Columbia Plateau are primarily from Priest Rapids Hatchery which integrates production with integrated with natural populations of fall Chinook in the Hanford Reach.



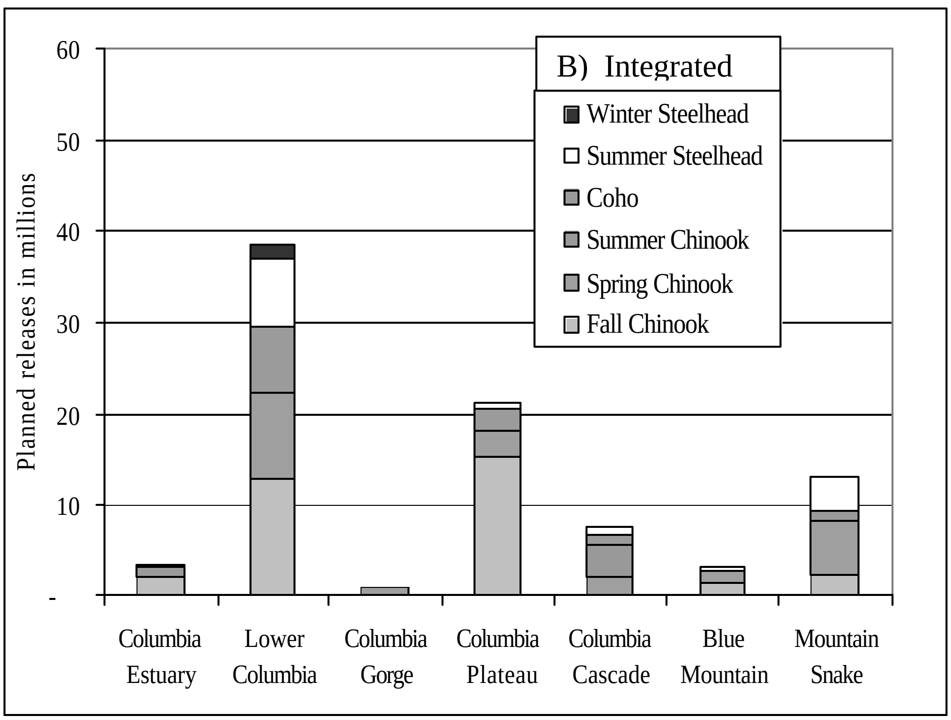


Figure IV-2: Distribution of planned releases of anadromous salmonids by cultural practice (integrated versus segregated), by species, and ecological province; A) Planned releases in segregated programs, B) planned releases in integrated programs

Evaluation of Hatchery Practices.

As stated earlier, segregated hatchery programs are intended to have minimal genetic exchange with wild populations and integrated programs are intended to have a controlled mixing to minimize genetic divergence of the hatchery and wild components. Therefore, it is appropriate to ask if the programs are achieving their intended levels of segregation or integration. A rigorous genetic study to answer these questions is beyond the scope of the APRE; however, the managers' responses to questions regarding broodstock choice, hatchery practices, and movement of fish between hatchery and wild components can give some insight into the question.

It appears that many segregated programs contribute significantly to wild spawning populations and, therefore, may allow gene flow from the hatchery to the wild population. For example, managers indicated that 30 percent of the segregated programs contributed more than 30 percent of the spawners in associated wild populations. Only in 20 percent of the segregated anadromous programs was there a contribution of less than 5 percent of naturally spawning hatchery fish to neighboring wild stocks. In addition, managers reported they did not know the level of contribution to wild spawners in 33 percent of the programs.

The controlled mixing of wild and hatchery components in integrated programs is more difficult to assess. There are no generally accepted standards defining the proper amount of mixing. However, HSRG has established guidelines that can at least serve as a point of comparison for current hatchery practices (HSRG 2002). The HSRG guidelines state that a program is well integrated if it incorporates at least 10 percent wild fish in the hatchery broodstock and if no more than 30 percent of the wild spawning escapement consists of hatchery fish. These criteria were met by only 20 percent of the integrated anadromous programs. About 53 percent of the integrated programs allowed more than 30 percent hatchery fish to mix with the wild component. Managers reported that, for 12 percent of the programs, they did not know the contribution of wild fish to the hatchery or how hatchery fish contribute to natural spawning.

The source of fish used in hatchery programs is also a measure of the degree of segregation and integration. For much of the last century, hatcheries were managed with little thought of the genetic aspects of population fitness and the importance of local adaptation. Fish were freely moved between streams and hatcheries at all life stages. If a hatchery did not receive its full broodstock needs from returns, broodstock might be imported from another hatchery with a surplus. Central hatchery facilities distributed juvenile fish from a single broodstock to many different streams. More recently, however, managers are recognizing the need to facilitate local adaptation of fish and to conserve locally adapted populations. Integrated programs in particular emphasize the use of local broodstock and attempt to minimize transfer of fish between facilities and streams. From a genetics standpoint, these practices may not be as important for a segregated program, but they may affect ultimate performance of the hatchery. Because some mixing of wild and segregated hatchery population inevitably occurs, the use of non-local broodstock can result in genetic impacts on associated wild populations.

As part of the APRE, managers were asked to describe the source of broodstock used in each hatchery program and to describe practices relating to transfer of fish between facilities at various life stages. Of the 102 integrated stock programs, 91 percent (93 programs) use broodstock derived from fish native to the subbasin where program fish are released and 81 percent (83 programs) avoid transferring and releasing fish from outside the subbasin. Of the 73 segregated programs, 41 percent (30 programs) used non-local broodstock and 63 percent (43 programs) transferred or released fish from outside the stream basin.

IV.C. Distribution of Hatchery Releases

Hatchery managers reported planned releases of 235,690,000 juvenile fish of all species from all hatchery programs in the U.S. portion of the Columbia River Basin. Actual releases in any year vary from this figure due to changes in hatchery operations, management priorities, or availability of brood stock. The planned releases, however, are an indication of the fishery managers' intentions and provide a basis for comparison between species, areas, and programs.

Of the total number of juvenile fish released from hatcheries in the Columbia River Basin, about 88 percent, or 207,734,500, are planned releases of anadromous salmonids below the anadromous passage barriers at Chief Joseph and Hells Canyon dams. The spatial and species distribution of anadromous salmonid releases clearly demonstrates how the Columbia River Basin hatchery system has been shaped by social and economic priorities (Figure IV-3). The largest proportion (42 percent) of anadromous salmonid releases comes from hatchery programs in the Lower Columbia province. Slightly less than 50 percent of the total planned releases of anadromous salmonids occur below Bonneville Dam (Estuary and Lower Columbia provinces combined). If releases from the Columbia Gorge province are included, most of which come from a few very large programs located just below and above Bonneville Dam, 65 percent of all anadromous salmonid releases come from the lower portion of the Columbia River.

This distribution reflects the mid-20th century policy of using hatcheries primarily to support commercial fisheries in the lower Columbia River and ocean fisheries off Oregon and Washington. About 55 percent of all anadromous salmonid planned releases in the Columbia River are fall Chinook (Figure IV-3) because fall Chinook are large contributors to the ocean troll fisheries. Spring Chinook, in contrast, are caught only in small numbers in the ocean commercial fisheries, although they are highly valued by the in-river and tribal ceremonial fisheries. In addition, as stated above, fall Chinook are released as fingerlings (sub-yearlings) which means that large numbers can be reared a lower cost than spring Chinook.

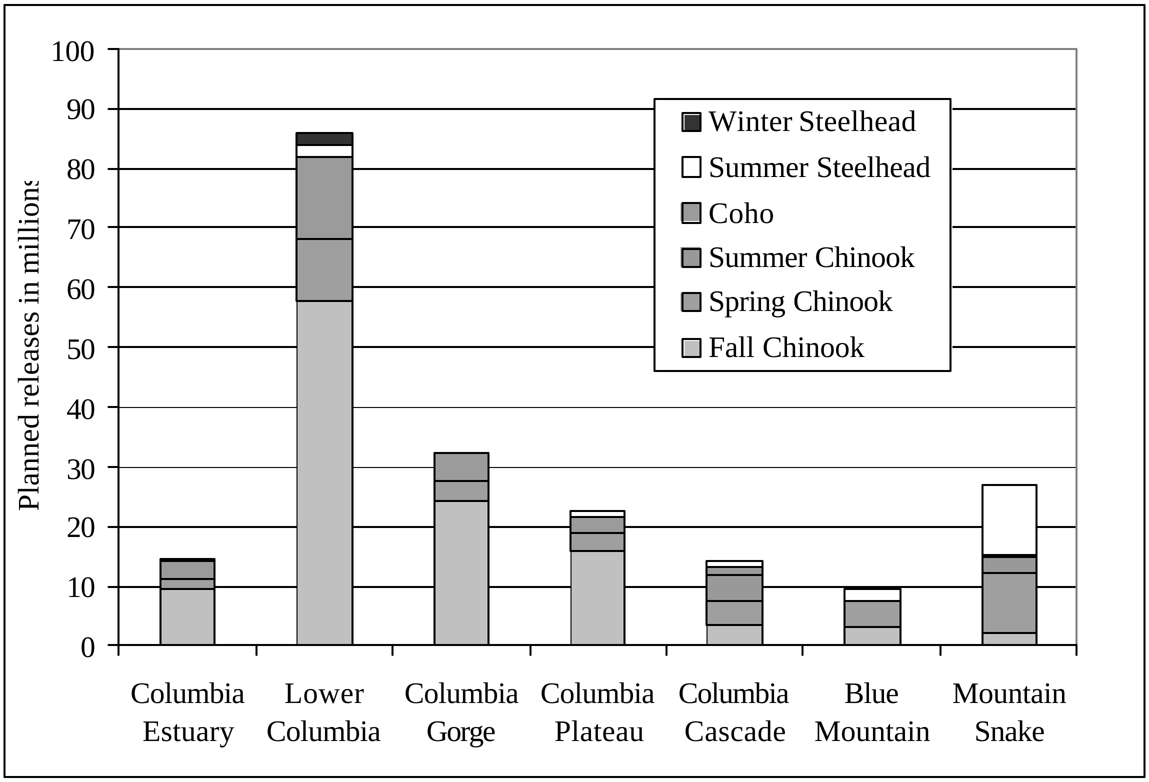


Figure IV-3: Distribution of planned hatchery releases by species across provinces.

Although the number of fish released in each province varies considerably, the number of programs releasing fish is relatively constant between provinces (Figure IV-3). The relationship between the number of programs and the number of fish released indicates that, in general, the lower river is dominated by a few very large programs, whereas the upper river has many smaller programs. Programs in the upper river areas are generally newer and many have been designed as integrated programs to raise a variety of species as opposed to the large segregated fall Chinook and coho programs in the lower river.

Almost all coho hatchery releases are from the lower Columbia River (Figure IV-3). The Estuary, Lower Columbia, and Columbia Gorge provinces account for about 85 percent of all coho releases in the Columbia River. Historically, coho were distributed throughout most of the accessible parts of the Columbia River Basin although they apparently were concentrated toward the mouth of the river (Mullen 1984). In addition, coho are major contributors to the commercial troll fisheries off Oregon and Washington. Hatcheries were developed in the lower river to support these fisheries. The result was a vigorous ocean fishery for coho with harvest rates of around 90 percent during the 1970s (Figure II-1). Naturally spawning populations could not sustain these high harvest rates and have now been largely extirpated (Johnson et al. 1991).

The largest proportion (37 percent) of anadromous salmonids released above the Columbia Gorge province comes from the Mountain Snake province (Figure IV-3). Most of these are spring Chinook and summer steelhead. Many of the hatchery programs in the Mountain Snake province represent mitigation programs for habitat lost to Hells Canyon Dam, the lower Snake River projects, and Dworshak Dam on the Clearwater River.

IV.D. Goals and purpose

Hatchery managers were asked to characterize the purpose of each artificial production program in terms of whether the program was intended to provide fish for harvest, contribute to conservation, or provide scientific research and educational opportunities. An individual program may serve all three purposes. For example, a program might be intended to contribute to rebuilding a wild population which eventually will provide a harvest opportunity. The program may also be used to educate school children about aquatic ecology.

Figure IV-4 shows that harvest remains the predominant purpose of hatchery programs in the Columbia River Basin. The majority of programs in all provinces identified Harvest as a purpose. In the upper Basin provinces, Conservation was nearly as important as Harvest. Research/Education was also identified as a purpose in a greater proportion of programs in the upper Basin, especially for Snake River hatcheries (Mountain Snake and Blue Mountain). These results are consistent with the original purposes for which hatcheries in the lower and upper rivers were constructed. As stated earlier, hatcheries in the lower river are generally older and were built to contribute to commercial harvests in the lower river and ocean. The upper river hatcheries are

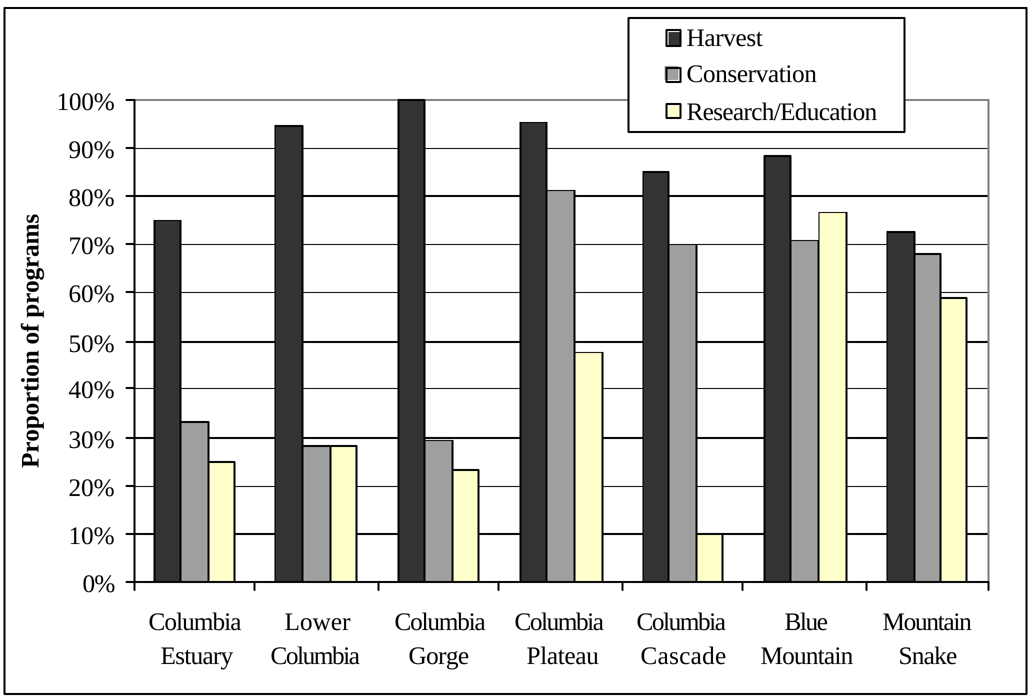


Figure IV-4. Distribution of purpose among artificial production programs in the Columbia River Basin. Bars represent the distribution of identified purpose within a province. Note that programs often have multiple purposes and add to more than 100 percent.

generally newer and built primarily to contribute to rebuilding natural populations while providing a harvest benefit, especially for tribal fisheries. Because the contribution of hatcheries to conservation through integrated programs is relatively new, hatchery programs in the Basin above the Columbia Gorge are more likely to be viewed as experiments and to be associated with monitoring and research efforts than are the older, segregated programs in the lower Basin.

IV.E. Funding

Few hatcheries are funded from a single source, making tracking funding of artificial production programs in the Columbia River Basin difficult. Hatcheries often receive funds from several sources contributing to specific programs. In addition, funds may be appropriated by one entity and administered by another. Other funds derive from the Bonneville Power Administration but are routed through reimbursements to other agencies. For example, the Lower Snake River Compensation Program supports numerous hatcheries on the Snake River, many of which are operated by the U.S. Fish and Wildlife Service through reimbursable funding from BPA. Finally, some sources contribute personnel and services while others provide capital and operating funds.

The APRE did not attempt to trace all hatchery funding as this was beyond the scope of the project; however, through the questionnaires, managers were asked to characterize the major funding for each hatchery program. This information is most useful in identifying the number of programs funded by various groups. It is not possible to say how much money each agency spends on which programs, on which species, and in which areas. Nevertheless, the managers' responses still tell much about the distribution of funding sources in the Columbia River Basin.

In Figure IV-5, "city funding" refers to mitigation hatchery funding by city utilities. For example, the City of Tacoma provides funding for hatcheries in the Cowlitz River as mitigation for hydroelectric dams operated by Tacoma PUD. The City of Portland provides partial support for hatcheries on the Sandy River to mitigate for Bull Run reservoir which supplies much of the city's water. "Private contributors" are private utilities such as Idaho Power Company, PacifiCorp, and PUDs operating in various counties, e.g. Grant, Douglas, and Chelan counties in Washington. These entities also fund hatcheries which mitigate for hydroelectric dams.

Funding for Columbia River Basin hatcheries derives from a variety of federal sources. Funds through the Mitchell Act (Section II.B) continue to support much of the hatchery production in the Basin, especially in the lower river. The Mitchell Act has funded hatcheries in the Columbia River since the 1940s. Mitchell Act hatcheries often are those that produce large numbers of fall Chinook and coho for harvest. The act also funds the Leavenworth National Fish Hatchery Complex (Leavenworth, Entiat, and Winthrop hatcheries) in the Columbia Cascade Province.

The Bonneville Power Administration (BPA) directly provides partial or complete funding for hatchery programs throughout the Basin through the Council's

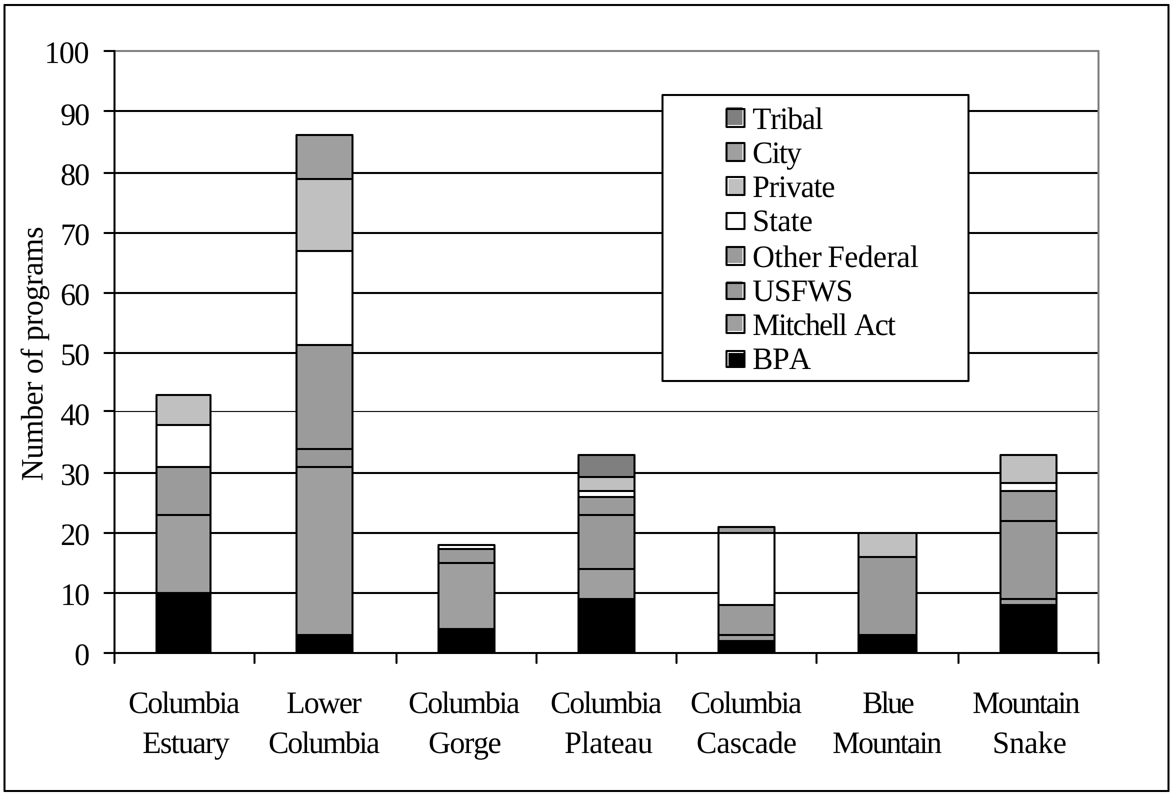


Figure IV-5: Funding and support for anadromous fish production programs in the Columbia River Basin. Support includes contributed personnel in addition to funding.

Fish and Wildlife Program. BPA programs in the Estuary province provide terminal area commercial harvest opportunities in the lower river. In the Columbia Plateau and Mountain Snake provinces, BPA programs are largely tribal operations that, in most cases, are integrated programs designed to augment natural production and support tribal fishers. In addition, BPA funds hatcheries through various indirect routes such as the Lower Snake River Compensation Program described above.

The U.S. Fish and Wildlife Service directly funds facilities such as the Warm Springs National Fish Hatchery on the Deschutes River (Columbia Plateau province). USFWS also funds hatcheries, as noted above, through the Lower Snake River Compensation Program. USFWS uses funds from the Army Corps of Engineers to support several programs in the Columbia Plateau, Blue Mountain and Mountain Snake provinces (Figure IV-5).

The category of “Other Federal” in Figure IV-5 refers to “other” Corps of Engineers funds which support hatcheries mitigating for hydroelectric and flood control projects. For example, the “Other Federal” funding in the Lower Columbia province represents Corps-funded facilities in the Willamette River operated by the State of Oregon.

"State and Tribal" funding can include monetary as well as "in kind" contributions of staff and supplies to operate facilities. For example, the Yakama Indian Nation has contributed staff to operate Yakima River facilities built with BPA funds.

IV.F Monitoring and Evaluation

The APRE did not attempt to catalog or assess ongoing research and evaluation in the Columbia River Basin associated with artificial production. However, as part of the APRE survey, managers were asked to supply information relating to the performance of each program. This information consisted of commonly reported fisheries statistics which could be used by hatchery operators to determine the success of their programs and account for their contribution to regional goals.

Table IV-2 summarizes information provided by the managers using four types of fisheries statistics: Recruits per Spawner, Smolt-to-Adult Survival, Escapement, and Total Catch. Less than 5 percent of the programs reported Recruits per Spawner, which is the ratio between the number of fish spawning and the number of fish estimated to contribute to fisheries and escapement. It is valuable as a measure of fish survival and their contribution to fisheries and spawning. The Smolt-to-Adult Survival measures the survival from the smolt stage to adult return and is a function of mortality factors associated with the hatchery as well as natural and artificial conditions encountered over the life cycle. This was the most common statistic reported by the managers. Escapement is the number of fish returning to spawn naturally or in the hatchery. The managers reported measuring Escapement for only about 21 percent of the programs. Total Catch is the number of fish the hatchery program contributes to all fisheries. This statistic was reported for about 33 percent of the programs.

Recruits per Spawner	4.6 percent
Smolt-to-Adult Survival	35.6 percent
Escapement	20.7 percent
Total Catch	33.3 percent

Table IV-2: Monitoring and evaluation statistics reported for anadromous fish hatchery programs in the Columbia River Basin

Chapter V. Discussion and Conclusions

The Congressional request for hatchery review and the Northwest Power and Conservation Council's subsequent instigation of the APRE was stimulated by the growing realization of the need for hatchery reform (Section I.A). The results of the APRE indicate that reform is essential for the hatchery system within the Columbia River Basin. The following discussion outlines the principles of hatchery reform and presents the general conclusions of the APRE project team.

Hatchery reform principles

The APRE based its approach to analysis and evaluation on that of the Hatchery Scientific Review Group (www.hatcheryreform.org) in Washington State, which had been instituted in response to a similar Congressional request. After four years of in-depth review of hatchery programs in the Puget Sound and coastal areas of Washington, the HSRG concluded that, for hatcheries to be successful, 3 principles must be adhered to:

- goals for stocks affected by hatcheries must be clearly articulated, expressed in terms of resource values, and reflective of current biological, economic, and cultural circumstances
- hatchery programs must be scientifically defensible
- decision-making about hatchery programming and operations must be responsive and well-informed

The application of these principles to the APRE produced a series of questions which were answered through analysis of the information collected through forms 1 and 2 and the accompanying interviews with fishery and hatchery managers.

(1) Establishment of Goals

In the APRE, goals for existing hatchery programs were identified and, where possible, the extent to which the goals were being achieved was evaluated. It became clear, however, that hatcheries are often managed without clearly stated goals. Goals are often vague or may conflict, negatively affecting success. In some cases, the goals that exist are not necessarily consistent with current social or conservation priorities.

To be successful, hatcheries must have clear and measurable goals reflecting priorities established by scientific thought, legislation, treaty agreements, and legal judgments. Goals must be periodically reviewed to make sure they are still consistent and relevant. The APRE review raised specific questions about goal setting for Basin hatcheries. These include:

- **Are the current goals for fish stocks in the Columbia consistent with the current biological, economic, cultural values and legal requirements?**

  The APRE analysis indicates that many programs are achieving their original objectives and goals. However, until the region clearly defines the role and future goals of hatcheries, it is difficult to determine how each program should be altered to best meet the goals.

- **Can anadromous fish production be better balanced to provide greater access to fish for communities upriver?**

  Many lower river hatchery programs are operated as mitigation for the construction of the Columbia River hydrosystem and provide fish to coastal and lower river communities. A sizeable majority of Columbia River Basin hatchery production takes place in the lower three provinces. Unfortunately, the communities most affected by the construction of the dams do not share equally in this production. Communities farther inland normally have less access to returning adults because of their geographic location. Columbia River Basin hatchery programs have exacerbated this situation by producing a disproportionate number of fish in the lower Columbia River. Attention should be given to the questions of whether and how to balance hatchery production.

- **Should more emphasis be placed on conservation relative to harvest for most stocks?**

  Managers need to ensure that the goals for their programs are consistent with currently required conservation, harvest, and educational objectives. Many of the Lower Columbia River programs are being managed primarily for harvest despite the presence of ESA-listed populations within their area. The NOAA 4 (d) guidelines state that the primary purpose of hatcheries affecting listed populations should be conservation (Section II.E).

- **Should less emphasis be placed on stocks produced primarily for commercial harvest?**

  With the rise of the salmon farming industry and the decline in ex-vessel prices for commercially harvested salmon (Section II.D), hatchery programs could produce fewer fish for commercial harvest. Many hatchery programs produce fish which are currently under utilized because it is not economically viable to catch them. This creates surpluses of adult fish at hatcheries and increases the risk of hatchery fish straying into unintended areas.

- **Can hatchery programs be used more strategically to better accommodate ecological and social goals?**

  Hatchery fall Chinook production is large relative to other hatchery programs in the Columbia River Basin. This production adds to the already large peak of Chinook returning in the fall of each year. Hatcheries could be used to enhance biodiversity by producing a wider variety of salmonid species and life histories. Greater species and life history diversity makes sense ecologically and could provide greater harvest opportunities by enhancing adult returns over a longer time period.

- **Are hatchery programs planned and operated consistent with the goals for all stocks of interest?**

  The data developed by the APRE show that little attention is paid to the cumulative effects of hatchery programs on native stocks both within and outside each subbasin or province. For example, only 60 percent of the programs indicated that the carrying capacity of the area where fish are released is considered in sizing the program. Additionally, only a few programs listed any legal or other restrictions that limited the number of hatchery fish released on a given year.

- **Should hatchery operators emphasize quality over quantity?**

  Many lower river hatcheries designed to support ocean fisheries release massive numbers of juvenile fish to achieve harvestable numbers of adult fish. The impacts on native populations and hatchery performance of a large number of juvenile hatchery fish entering the relatively small Columbia River estuary has not been considered. Mitigation agreements dictate that hatcheries release prescribed numbers or even poundage of juvenile fish regardless of success in production of adult returns. Conservation hatcheries are increasingly emphasizing release of smaller numbers of juveniles more closely resembling their natural counterparts in morphology, behavior, and run timing. Balancing biological requirements of the fish with scientific constraints and legal mandates must be addressed when establishing goals of hatcheries and individual programs.

- **How many hatchery fish should be released each year?**

  Hatchery releases should be sized to achieve identified goals consistent with the ecological context of the hatchery program. In practice, this is difficult to define as changing freshwater and ocean conditions dramatically influence resulting adult production. As a result, goals are likely to be met in some years, but not in others. In addition, changing harvest management practices also impact the number of fish caught in fisheries and the number returning to the Basin. Variable hatchery returns to the Basin can be problematic for wild fish. In large return years, the number of hatchery fish on the spawning grounds may exceed HSRG guidelines, resulting in more risk to wild fish. In low productivity years, insufficient numbers of wild fish may return to maintain the genetic mix required to maintain a properly integrated hatchery program. Hatchery production levels need to take into consideration both high and low production conditions in order to accommodate the risks posed to conservation and harvest goals.

- **When should hatchery production be reduced?**

  The data show that, historically, the hatcheries have sought to increase rather than reduce production, generally to meet the primary goal of achieving harvest benefits. For programs where conservation becomes the primary concern, it may be necessary to reduce hatchery production. The HSRG guidelines propose a self-limiting approach to hatchery production based on the composition of the run returning to the Basin. The HSRG calls for strict adherence to the number of hatchery fish allowed to spawn with wild fish and the number of wild fish used as hatchery broodstock. If the guidelines cannot be met, hatchery production must be reduced to a level where they can. The values are not an average, but are limits that must be achieved each year.

- **Should more hatchery programs be integrated rather than segregated?**

  This question involves the goals to be achieved and the amounts of risk managers are willing to accept to achieve them. The HSRG guidelines allow for the use of both approaches, but put different restrictions on each. The Council has identified areas where habitat is fundamentally altered or blocked, with no possibility of recovery, as potential choices for locating replacement hatcheries to provide harvest and conservation benefits (Table II-2). These areas may be the best choice for locating segregated programs designed to provide harvest benefits primarily. Additionally, NOAA has stated that hatcheries affecting listed stocks must have as their primary purpose the conservation of that species. This would seem to indicate that many of the segregated programs in the Lower Columbia need to be converted to integrated programs. A scientifically credible rationale needs to be established for the management of each program, goals need to be explicitly stated, and the expected benefits and risks clearly defined in order to answer this question.

(2) Scientific Defensibility

Current scientific knowledge should determine and guide the use of hatcheries. Given that natural resource science acts within the context of continually changing social priorities, the scientific foundation for strategies such as artificial production is best viewed as a "working hypothesis."[1]

The HSRG developed a scientific framework for hatchery reform that can serve as a basis for working hypotheses for hatchery use (HSRG 2002). The framework includes guidelines for operating hatcheries to meet goals for the target stock while minimizing adverse genetic and ecological interactions on natural populations. Guidelines are matched to the purpose of hatchery programs (harvest, conservation, education, etc) and type (integrated vs. segregated) of hatchery program.

Key HSRG guidelines include:

- <u>Programs should facilitate local adaptation by hatchery and natural population components.</u>

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[1] A working hypothesis is a depiction of the scientific logic behind an action and which is constructed in a manner facilitating scientific testing and refinement over time. It does not represent certainty and may, in fact, incorporate considerable uncertainty regarding future conditions and existing knowledge. Nonetheless, a working hypothesis represents a logic trail that provides scientific accountability for actions.

All artificial production programs should strive to operate in a manner that promotes local adaptation. This means that broodstock native to, or likely to adapt to, the watershed where they will be released should be chosen so that the program perpetuates only adults returning to the same watershed. No importation of broodstock from outside a stream basin should be allowed. The APRE indicated that 38 percent of anadromous hatchery programs imported broodstock from out of subbasin. Out-of-basin rearing should also be avoided; 42 percent of the anadromous programs relied to some extent on rearing facilities outside the stream basin where the fish were released.

- Integrated programs are intended to directly benefit a natural stock (through supplementation) and/or increase its abundance without adversely affecting the natural stock

  Integrated hatchery programs should meet minimum criteria for wild fish contribution to the hatchery broodstock and maximum criteria for the contribution of hatchery fish to the natural spawning escapement. Less than half of anadromous programs included 10 percent or more wild fish in the hatchery broodstock and less than half of those programs limited hatchery contribution to 30 percent or less of the wild escapement. Hatchery practices employed for integrated programs should also attempt to minimize the effects of domestication. For example, less than half of the anadromous programs rear fish under natural temperature regimes and no more than 10 percent produce fish with growth rates similar to wild fish.

- The management intent for segregated hatchery programs is to minimize all interaction with wild stocks.

  Straying of hatchery returns should be minimized. Only 16 percent of the segregated anadromous programs were reported to contribute less than 5 percent of the spawning escapement of any wild stock. Less than half of the programs indicated that they had a goal for hatchery-wild composition.

  One way to reduce the potential for competition and predation at juvenile life stages is to assure that hatchery fish are "migration ready." Less than half of the programs practiced volitional releases during the natural outmigration time period.

The APRE found that few hatchery programs adhere to all key guidelines identified by the HSRG, suggesting ample room for improvement in the performance of hatchery programs. Significant improvements in long term survival can be achieved through such measures as avoidance of stock transfers and culture practices that reduce domestication. Adopting and adhering to stricter guidelines for proper integration and segregation of hatchery stock can minimize the effects of negative interactions with wild stocks.

(3) Informed decision-making:

Hatcheries reflect a considerable investment in public funds and have implications that can extend far into the future. For these reasons, hatcheries need to be operated in a "business-like" way, where successes and failures are observed and responded to by managers accountable for their success. A "culture" that discourages outside scrutiny cannot be allowed to continue; all hatchery programs must be thoroughly examined

For decision-makers to be successful, they must be informed about potential problems in a timely and must act on the basis of factual and complete information. Gathering and disseminating information and a commitment to continued monitoring of hatchery programs are essential. One of the most alarming results of the APRE is the frequency of the "Do not know" response to key questions regarding performance and the impact of hatcheries on surrounding stocks (Table IV-2). Managers often are not able to answer the most basic questions regarding the success or potential harm caused by hatchery programs. Information about hatchery performance is often poorly evaluated and inaccessible. For example, while a majority of the hatchery programs listed harvest as a primary goal, less than 1/3 provided data on the number of fish harvested and fewer still provided total Recruit per Spawner information.

While there is a critical need for more monitoring both from within and outside the hatchery, there is an even more urgent need to improve analysis and distribution of existing data to all personnel involved in management and operation of hatchery programs. Success of hatchery operations is still too frequently measured in terms of numbers of fish released regardless of the number of adults eventually produced from those releases.

Indicators and standards that directly or indirectly relate to success need to be defined and measured regularly The results must be evaluated and effectively communicated so that informed and responsive decisions can be made at all levels of management and operations. The APRE information revealed that programming and operational decisions for most hatchery programs were reported to be based on "adaptive management." Also, most programs reported that standards for in-culture performance were specified and met. Most programs reported that goals for Smolt-to-Adult Survival, Recruits per Spawner, and other post-release performance standards were specified, but few programs computed these indicators each year.

In reviewing the programs throughout the Basin, it was found that the majority of hatchery operators were eager to share their knowledge and provide constructive suggestions for the improvement of hatchery operations. A frequent complaint heard from hatchery staff was that the drive to meet production goals interfered with good fish culture practices. At times, fish are released on a schedule based not on biology, but on the need to free-up space for another species or life-stage. The decision to emphasize quantity over quality poses risks that need to be better documented and monitored. There appears to be a need for better communication between the managers designing the programs and the operators producing the fish.

General Conclusions

The Artificial Production Review and Evaluation process is the most comprehensive review of hatchery programs in the Columbia River Basin to date. In addition to the conclusions related to the HSRG key guidelines stated above, four general conclusions emerged from this review:

1) Hatcheries are limited in what they can accomplish.

   Hatcheries were once seen as a panacea that would allow unrestrained fishing and development in the Columbia River Basin. Hatcheries promised to make up for the loss of fish abundance that resulted from construction and operation of the Columbia River hydroelectric system and other development activities. Clearly, this result has not been achieved. Despite massive hatchery programs, current adult returns to the Columbia River Basin fall far below historical estimates. However, because the present relatively modest returns of anadromous salmonids to the Columbia River Basin are made up in large part of hatchery fish, it is arguable that the current abundance of fish would not exist without hatchery production. Nonetheless, the disparity between current and historical abundance, despite the significant infusion of hatchery fish, clearly indicates that hatcheries are, at best, an incomplete solution to the problems of habitat loss and over-harvest. In fact, hatchery fish, like wild fish, require healthy receiving habitat in order to be successful. Most importantly, integrated conservation programs are based on the premise that habitat conditions will improve over time.

2) The social, ecological, and economic purposes upon which the current hatchery programs were established have changed and will continue to change.

   Hatcheries have been used to achieve social, legal and economic goals. Until relatively recently, hatchery programs were intended almost solely to support non-Indian commercial fisheries in the ocean and lower river. Existence values, spiritual values, and conservation were rarely considered in placement or development of hatchery programs. Mitigation was a matter of balancing the equation between the potential loss of fish to fisheries and the pounds of fish biomass released from hatcheries. This approach is the foundation of most of the hatchery programs in the Columbia River Basin. In the 1960s and 1970s, thriving commercial fisheries existed in the lower Columbia River and in the oceans off Oregon, Washington, British Columbia, and Southeast Alaska. These fisheries were supported to a large degree by Columbia River hatchery programs. The fact that wild runs declined in large part due to over-harvest, in addition to the loss of habitat, was not viewed as a crisis but rather as a demonstration of the inefficiency of nature compared to that of hatcheries.

   The latter part of the 20th century, however, saw a shift in the underlying social basis for hatcheries. Conservation of the environment, ecosystems, and species became important national and local priorities. The importance of Indian spiritual and cultural values was legally recognized. At the same time, the commercial salmon fishing industry began to decline due to rising costs, conflicts with conservation concerns and competing sources of salmon such as aquaculture.

This decline continues today. Judged on current priorities, hatcheries are often found lacking and have been subject to criticism from many quarters. In fact, it can be concluded from the results presented in this report that the Columbia River hatchery program for the most part continues to be operated under the social paradigm of the mid 20th century. Although changes have been made in recent years, most hatchery releases still originate from lower river facilities which release large numbers of fall Chinook and coho intended for commercial fisheries. Likewise, past hatchery practices (such as the use of non-local broodstock) continue to be employed in some facilities in order to meet production goals.

It is perhaps to be expected that hatcheries will continue to be imperfect solutions to past problems. Nonetheless, a conscientious and systematic review of the goals and practices of hatchery programs is required in order to improve the alignment between the use of hatcheries as a tool and social/environmental priorities. Existing legal mandates, agreements, and legislation may need to be reviewed and changed to allow the flexibility to use hatcheries in ways which reflect current scientific thinking and social priorities.

3) <u>Hatcheries will continue to play a part in recovery and management of fish in the Columbia River and elsewhere.</u>

Hatcheries present a myriad of problems (Section II.F), yet critics of hatcheries rarely provide viable alternatives. Hatcheries appear to be the only alternative in order to mitigate for habitat lost to development and to honor treaty obligations while retaining the benefits of hydroelectricity, agricultural irrigation, transportation, and flood control. Therefore, hatcheries appear to be part of the solution to maintaining viable fish runs in the Columbia River system. For example, hatcheries still offer the only way to mitigate for fish habitat lost to construction of a dam without fish passage facilities. In addition, hatcheries may offer the only means of providing sufficiently productive stocks to allow the continuation of tribal fisheries above Bonneville Dam.

4) <u>Hatcheries require reform</u>.

Finally, it is concluded that these considerations and the results of the APRE review point to the need for hatchery program reform. While reform of the system may result in closure of some hatcheries, hatchery elimination *per se* is not advocated. Hatchery reform is needed to:

- align hatchery policies and practices with current social priorities and scientific knowledge
- determine hatchery performance
- operate hatcheries in a business-like fashion

As discussed above, determination of hatchery performance requires collection of appropriate information. It appears that most hatcheries do not do this. Performance and its impact on other priorities often cannot be determined for a given hatchery. What should be routine monitoring and data collection is often sacrificed to budget priorities because of the perceived need to maintain production numbers. The result of this is that it is impossible to assess the performance of hatchery programs or to distinguish successful from unsuccessful programs.

As important, and also frequently inadequate, is the evaluation and communication of monitoring results. The lack of good monitoring and timely evaluation makes hatchery programs vulnerable to possible elimination due to the lack of careful consideration of their contributions to conservation or other goals.

Reform requires that hatcheries operate in a business-like manner. As discussed above, hatcheries must be operated so that successes and failures are observed and responded to by managers who are accountable. Data and information must be available to all hatchery management and operations personnel and communications among and between entities involved in hatchery management and operations must be complete and uninterrupted. After application of business principles, hatcheries that are successful should be retained, while those that are not should be eliminated.

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