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POLICIES AND PROCEDURES FOR COLUMBIA BASIN ANADROMOUS SALMONID HATCHERIES

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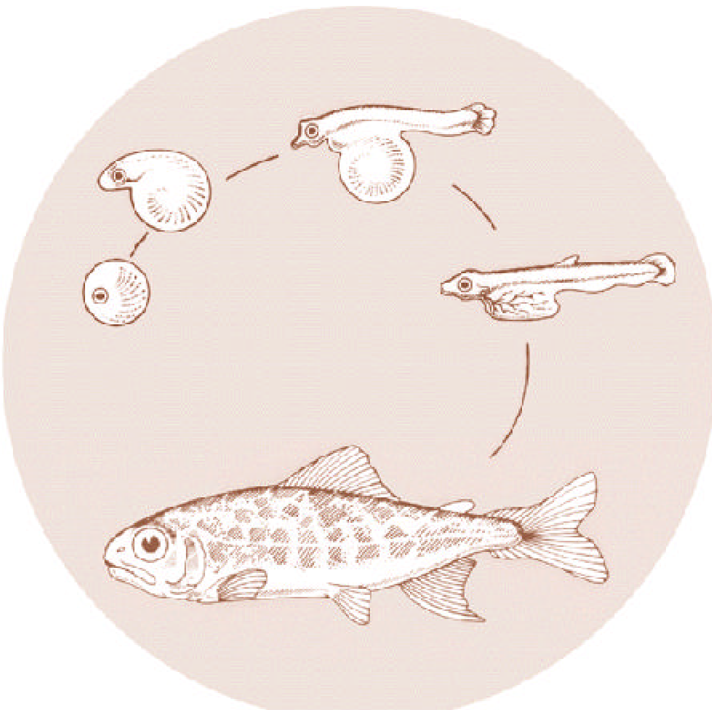

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POLICIES AND PROCEDURES FOR COLUMBIA BASIN ANADROMOUS SALMONID HATCHERIES

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Preface

This document outlines regional policies and procedures for hatchery operations in the Columbia River Basin. The purpose of these policies is to provide regional guidelines by which all anadromous fish hatcheries will be operated. These policies will be adopted by the fisheries co-managers, and will provide guidance to operate hatcheries in an efficient and biologically sound manner.

The hatchery policies presented in this manual are not intended to establish production priorities. Rather, the intent is to guide hatchery operations once production numbers are established. Hatchery operations discussed in this report include broodstock collection, spawning, incubation of eggs, fish rearing and feeding, fish release, equipment maintenance and operations, and personnel training. Decisions regarding production priorities must be provided by fishery managers through a comprehensive plan that addresses both natural and hatchery fish production.

The Integrated Hatchery Operations Team is a multi-agency group called for by the Northwest Power Planning Council. This team was directed to develop new basinwide policies for managing and operating all existing and future anadromous fish hatcheries in the Columbia River Basin. The parties pledge to confer with each other and to use their authorities and resources to accomplish **these** mutually acceptable hatchery practices.

Integrated Hatchery Operations Team
June 1994

Chapter 1

Introduction

BACKGROUND

There are more than 90 hatchery facilities in the Columbia River Basin currently used to produce salmon and steelhead. These facilities are funded, co-managed, and operated by many different entities for many different purposes. Most of the region's hatcheries were originally authorized and built to mitigate for fish habitat losses caused by construction and operation of dams and other water projects. Today, these facilities produce fish for many different management objectives, including supplementation, restoration, harvest, egg banking, and research. Together, they produce approximately 75 percent of the basin's adult salmonid runs.

Because hatcheries are operated by several entities and for different purposes, these facilities have often used different guidelines for operating hatcheries. The need to improve the coordination and operation of these facilities was formally recognized in the Northwest Power Planning Council's Strategy for Salmon (NPPC 1992). This salmon strategy is a regional effort to try and double existing adult salmon populations in the Columbia River Basin without losing biological diversity.

In developing its salmon strategy, the Council recognized that hatcheries could be used to help rebuild wild and naturally spawning stocks. However, it would require the development of consistent hatchery practices that would enable hatchery fish to survive in the natural environment without adversely impacting the naturally spawning fish. To meet this need, the Council called for the creation of an Integrated Hatchery Operations Team (IHOT). This multi-agency group was given several duties related to hatchery operations. In particular, MOT was asked to develop regionally integrated hatchery policies for -operating Columbia Basin hatcheries.

This document details the regional policies and procedures developed by the Integrated Hatchery Operations Team. Its purpose is to help ensure that hatchery operations will be consistent with the regional goal of rebuilding wild and naturally spawning fish runs.

THE ROLE OF HATCHERIES

Hatcheries are a fisheries management tool used to substitute for portions of the natural life cycle of fishes. Over the past century, these facilities have played an important role in meeting management goals for restoring, maintaining, and enhancing fish populations.

It is expected that hatcheries will continue to play an important role, even as the region increases its emphasis on rebuilding wild and naturally spawning stocks. For example, in areas where suitable environmental conditions are restored, artificial propagation may be used in conjunction with other rehabilitation measures to assist in recovery of wild or natural populations. In areas where habitat has been permanently lost, or environmental conditions cannot sustain natural populations, artificial propagation may be used to establish and maintain replacement populations.

The use of hatcheries for enhancing natural production will require some changes from existing operating procedures. Hatchery programs should utilize existing baseline data for establishing both operating guidelines and fish quality criteria that will improve hatchery operations. This will help achieve the rebuilding of wild and naturally spawning stocks, while also continuing to provide fish for commercial, recreational, and tribal fisheries.

Finally, it is important to note that hatchery operations are just one of the tools used to meet fish management objectives. As outlined in the Council's Strategy for Salmon, rebuilding Columbia Basin fish runs will come from a mix of wild, natural and artificial production. To the degree that habitat constraints on wild and natural populations are corrected, fish harvests are managed to support rebuilding, and populations increase, the role of artificial production will continue to change.

SCOPE AND FORMAT

This manual presents regional policies for hatchery coordination, hatchery performance standards, fish health, ecological interactions, and genetics. These new policies and procedures are designed to serve as guidelines by which all anadromous fish hatcheries in the Columbia River Basin will be operated.

The remainder of this document is divided into six chapters.

Chapter ***Z-Administrative*** Matters provides a list of IHOT representatives and a brief overview of the role this team has agreed to perform. Each of the remaining chapters is devoted to the policy areas as described below.

Chapter 3-Regional Hatchery Coordination Policy identifies measures for coordinating hatchery operations in the region. It also describes proposed actions to facilitate the sharing of facilities, manpower and other resources.

Chapter 4-Hatche y Performance Standards Policy presents regional standards for hatchery facilities and operations. It discusses a wide range of facility requirements, including water quality, alarm systems, adult collection/holding, and incubation, rearing and release facilities. Some of the operational activities discussed include egg incubation, fish rearing, and training'of hatchery personnel.

Chapter 5-Fish Health Policy details hatchery practices and operations designed to stop the introduction and/or spread of any fish diseases within the Columbia Basin.

Chapter 6--Ecological Interactions Policy identifies measures needed to help avoid adverse interactions between wild, natural and hatchery fish populations. Specific items addressed in this section include the location and timing of fish releases, fish size at release, release densities, and hatchery rearing conditions that can influence future ecological interactions.

Chapter 7-Genetics Policy contains guidelines for broodstock selection and 'spawning practices. These guidelines are designed to help avoid adverse genetic effects on wild, natural and hatchery fish populations.

Within each policy chapter, IHOT identifies a policy statement and goals, performance standards and performance measures. The policy statements and goals reflect an overall policy direction that IHOT members have agreed to pursue in operating the region's fish hatcheries. The actual procedures and standards that will be used to guide hatchery operations are identified as performance ***standards. The*** *performance* measures describe how the hatchery's compliance with the standards will be monitored and evaluated. Most chapters conclude with an *implementation* ***plan*** detailing actions that will be used to implement the individual policies and procedures.

Chapter 2

Administrative Matters

PARTIES

The Integrated Hatchery Operations Team is comprised of representatives from the following fisheries co-managers and cooperating entities:

<u>Fisheries Co-Managers</u>
Confederated Tribes of the Colville Reservation
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of the Warm Springs Reservation of Oregon
Confederated Tribes and Bands of the Yakama Indian Nation
Idaho Department of Fish and Game
National Marine Fisheries Service
Nez Perce Tribe of Idaho
Oregon Department of Fish and Wildlife
Shoshone-Bannock Tribes of Fort Hall
U.S. Fish and Wildlife Service
Washington Department of Fish and Wildlife

<u>Cooperating Entities</u>
Bonneville Power Administration
Mid-Columbia Public Utility Districts
U.S. Army Corps of Engineers
Northwest Power Planning Council
Pacific Northwest Utilities Conference Committee
Columbia River Inter-Tribal Fish Commission
Columbia Basin Fish and Wildlife Authority

SCOPE AND NATURE OF AGREEMENT

In order to meet the responsibilities outlined by the Northwest Power Planning Council, IHOT will:

1. Coordinate anadromous salmonid hatchery operations among fisheries co-managers within the Columbia River Basin.

2. Provide oversight and review of hatchery audits, and will provide recommendations as appropriate.

3. Maintain a continuing review of regional policy implementation and will recommend changes when appropriate.

4. Monitor compliance with hatchery performance standards through a coordinated hatchery monitoring program.

Chapter 3

Regional Hatchery Coordination Policy

Basinwide resource needs can be most effectively addressed when hatchery operations are coordinated throughout the region. This coordination can be within an individual agency or between several agencies and co-managers within the basin. Coordination can also be used at different levels to meet various organizational needs. For example, staffing or equipment needs can be coordinated to meet a common goal. Coordination can also occur at the programmatic or administrative levels to achieve broader regional goals.

POLICY STATEMENT AND GOALS

Policy Statement

It shall be the policy of the management entities of the anadromous salmonid resources in the Columbia Basin to coordinate the operation of fish hatchery programs to meet basinwide resource management needs.

Goals

1. Coordinate the operation of salmonid hatchery programs to meet basinwide resource management goals and objectives.
2. Develop administrative agreements for improved sharing of facilities, manpower, equipment and/or supplies to meet basinwide management program goals and objectives.
3. Foster open and frequent communication between managing entities to coordinate and jointly resolve technical issues relating to artificial production.
4. Operate hatchery programs in compliance with regionally adopted genetics, fish health, ecological interactions, and hatchery performance policies.

PERFORMANCE STANDARDS

Current and proposed hatchery production must be consistent with requirements of existing authorizations and agreements. These include the Endangered Species Act, the Columbia River Fish Management Plan (U.S. v. Oregon), the Council's Fish and Wildlife Program, and individual state/tribal fishery programs.

Operational Coordination

1. Provide a common forum that will facilitate sharing of facilities, manpower, and equipment to meet regional objectives.
2. Provide a common means of cost/ time sharing of resources for efficient facility operations.
3. Provide a forum to share information among hatchery operational staff.

Programmatic Coordination

1. Review hatchery operations on a basinwide level to meet goals expressed in legal agreements, hatchery operational plans, regional policies, and agency/tribal programs.

2. Meet regularly with the full IHOT membership to discuss programmatic and administrative matters, including hatchery audit reviews.

3. Regularly review fish survival data and other research projects that provide fishery survival/contribution information.

PERFORMANCE MEASURES

Several reports and operational procedures will be needed to measure the effectiveness of the regional hatchery coordination standards. These items are described below.

1. Within one year of ratification, MOT will create a memorandum of understanding between members for the sharing of facilities, manpower, and equipment.

2. IHOT members will prepare an annual report that details shared resources.

3. The MOT facilitator will serve as a central distribution point for reports pertaining to fish hatchery operations.

4. Meetings-of the full MOT membership will occur regularly to discuss programmatic and administrative matters. The meeting schedule will be established by MOT chairperson.

5. The IHOT facilitator will maintain an electronic bulletin board for sharing Current and Future Brood documents, and for the free distribution of information among members.

6. The MOT facilitator will provide the means for timely reporting of fish escapement, transfer, and release goals and the progress being made to meet the objectives. Coordination of personnel and equipment sharing will be recorded and records maintained through the MOT facilitator.

7. Agencies will update hatchery operation plans yearly.

8. Co-managers that operate fish rearing facilities will adopt common formats for reports developed within the basin (e.g., Annual Brood Planning Report, U.S. *v.* Oregon, etc.).

9. MOT members will present a yearly report of all fish culture research proposed, in progress, or completed.

10. IHOT members will present annual updates of current fish survival information.

IMPLEMENTATION

1. Managing entities will use MOT to foster open and frequent communication. This will allow IHOT members to coordinate and jointly resolve technical issues relating to hatchery operations. All management entities must participate to ensure that hatcheries are integrated into a basinwide system of planned production. Coordination with legal or specialized committees (e.g., Production Advisory Committee, Pacific Northwest Fish Health Protection Committee, Technical Advisory Committee) will be coordinated through their respective chairpersons.

2. Administrative agreements will be developed to enhance efficiency in meeting basinwide management goals. These agreements will include sharing of manpower, equipment, and supplies.

3. Hatchery operations data will be exchanged via the Coordinated Information System (CIS).

4. MOT will support activities that encourage the exchange of hatchery information and technology among Columbia Basin fish hatcheries.

Chapter 4

Hatchery Performance Standards Policy

Producing fish in a hatchery is not just a matter of science, it also . somewhat of an art. As an art, fish culture is governed by specific hatchery operational requirements that directly influence the hatchery's production. Some of the major factors affecting fish production include:

- Biological requirements of the fish stocks
- Water quality parameters that influence hatchery production
- The types of rearing containers utilized and their water supply and flow patterns
- Fish nutrition requirements and feeding regimes
- Activities associated with all aspects of the hatchery operation from adult collection through release
- Release strategies and liberation units used for fish transfer and release

Making the transition from the art of fish culture to scientifically applied knowledge is the key to improving the quality of hatchery-produced fish. As used here, quality is defined as increasing the yield to the fishery and escapement to spawning areas, while also maintaining desired genetic traits and reducing incidence of disease.

Quality is improved by recognizing the origin and status of individual fish stocks, and the conditions that influence these stocks. It should be recognized that fishery contributions from hatcheries are influenced by production goals established through a variety of fish management, political, and administrative processes. The politician, administrator, fish biologist and hatchery manager should understand the production potential and constraints of the hatchery rearing facilities. However, they must also understand the overriding influences (e.g., ocean conditions and in-river environmental alterations) that control production capacity.

The technology needed to produce quality hatchery fish already exists. New scientific information can be used for adjusting hatchery operations to lessen or eliminate the impact of hatchery fish on wild stocks. Existing hatchery management practices should be the baseline for identifying concerns, progress, and future requirements to successfully provide efficient artificial production.

POLICY STATEMENT AND GOALS

Policy Statement

It shall be the policy of the management entities of the anadromous salmonid resources'in the Columbia Basin to ensure that all hatchery practices are based on regional standards.

Goals

1. All fish produced and released are consistent with management goals.

2. Physical facilities and equipment are operated consistent with standards to maximize fish quality.

3. Ensure compliance with hatchery coordination, fish health, ecological interactions, and genetics policies.

4. Ensure the use of an audit framework to evaluate the compliance of hatchery operations with regional standards.

PERFORMANCE STANDARDS

"Performance standards are intended to provide a point of reference against which to monitor change, and units of measure to define change" (NPPC 1992).

Over the past two decades, there have been many research studies and plans initiated to (1) improve the quantity and quality of fish produced in Columbia Basin hatcheries, and (2) determine their impact on wild fish populations. However, the additional questions raised about these issues have identified the need for a consistent basinwide evaluation of existing hatchery programs and facilities.

The evaluation scenario presented in this report establishes a process for making changes that can improve hatchery operations. Performance standards will encompass all aspects of hatchery facilities and operations that influence the hatchery's "final product." As used here, the hatchery's desired final product is a fish that has minimal impact on wild stocks and also contributes to harvest opportunities and natural spawning populations.

It is again important to note that the standards and measures presented in this report are not intended to set specific production priorities. Instead, they are to help guide hatchery operations once the production programs are approved by the fishery managers. The standards are also the basis for hatchery performance audits.

Performance standards for consistent basinwide hatchery practices are presented in sections below. These standards are divided into the following three categories:

- Program objectives
- Facility requirements
- Hatchery operations

Performance Standards for Program Objectives

The performance standards outlined in this section address operational procedures directly controlled by the hatchery. These standards reflect the importance of meeting goals outlined in existing management plans. Hatchery production programs must ensure that all fish produced and released meet the specific and collective requirements of existing programs and statutes.

Most of the Columbia Basin hatcheries were initially authorized and constructed as mitigation projects. This mitigation was either for fish habitat losses at specific project locations or because of fishery impacts caused by multiple water-use projects throughout the basin. Recent actions, however, have restructured the priorities for hatchery use. Current and proposed hatchery production must be consistent with requirements of several existing authorizations and agreements. These include the Endangered Species Act, the U.S. v. Oregon Columbia River Fish Management Plan, the Council's Fish and Wildlife Program, the Columbia Basin Fish and Wildlife Authority's (CBFWA) Integrated System Plan, and individual state/tribal fishery programs.

There is a great deal of merit in releasing viable fish from traditional hatcheries to provide harvest augmentation (the stocking of anadromous fish where the primary purpose is to return adults for sport, commercial, or tribal harvest) as described by Miller et al. (1990). Hatchery production will also be needed to provide for natural spawning augmentation in order to meet the Council's interim doubling goal. This is accomplished by producing eggs and/or fish that are qualitatively similar to the size, physiological status, and life stage as the existing natural spawning species, while meeting known ecological, genetic, and fish health guidelines.

The use of hatcheries for enhancing natural spawning populations will require some changes to the existing operating procedures. These operational changes include (1) how eggs are obtained, (2) the process for handling eggs and fry, and (3) the release strategies used to match fish to the environment.

In addition to performance standards and measures described in this chapter, hatcheries providing fish for either harvest augmentation or rebuilding natural spawning populations will also follow the goals, standards, performance measures, and implementation procedures associated with the other regional policies. Risk assessment will be addressed by these policies.

The production of hatchery fish for natural spawning augmentation will occur in existing and new facilities. Handling of eggs and fish will generally follow the hatchery performance standards, and measures described in this document. Suggestions for experimental hatchery treatments that could create more natural conditions for hatchery fish are presented in Appendix A.

Assessment of new hatchery technology, using an adaptive management policy framework, is based on the following basic assumptions:

1. Assessment is a policy tool.

2. Assessment is likely to be repetitive, and part of inter-related studies.

3. **New** technology **creates** new **questions.**

4. Long-range, indirect effects of **a** technology are often more significant than immediate **or** planned consequences.

5. By learning from the implementation of new technologies, the resource managers, Northwest Power Planning Council, and hydropower ratepayers will act affirmatively on behalf of fish.

It is important that all evaluations of new rearing techniques be based on appropriate experimental procedures. As reported by Lichatowich and Watson (1993), considerations of statistical methods during development of the research proposal are needed to assure data will be gathered that can be properly analyzed.

Performance Standards for Facility Requirements

The physical production capacity of a hatchery is dependent on several biochemical and spatial features. For example, **the** biological traits of the fish stock, nutritional requirements, the types of rearing containers, water quality, and the overall management all have important standards that must be met.

Existing facilities in the Columbia Basin are of various **ages** and have evolved under a multitude of administrations and funding levels. This has resulted in a variety of installations in poor-to-good condition with outdated-to-modern features. Most of these facilities were originally developed to meet management needs different from today's needs. A facility review, which is based **on** performance standards and measures, should lead to recommended improvements for those facilities having correctable problems. It is incumbent on the appropriate co-managers to identify deficiencies and constraints, and on the funding entities to provide funds for needed alterations or improvements identified through the review process.

Water Quality

Specific water quality requirements for hatchery fish vary with the seasons of the year and life-cycle stage. Water quality is the single most important factor in maintaining an acceptable environment for hatchery fish. Because water quality is so critical for good fish husbandry, it is important to identify standards for the more important water quality parameters (i.e., **temperature,** dissolved gasses, chemistry, turbidity, toxic materials, and pathogens). Specific water quality criteria for salmonid aquaculture are provided in Appendix B.

Temperature

The temperature of water used in salmon hatcheries influences growth and development, fish health, and the physiological process of smoltification. Generally, salmonids rear best at temperatures between 48°F and 60°F. With lower temperatures, development and growth may be too slow to achieve program objectives, while temperatures between 55°F and 70°F may encourage certain diseases (Piper et al. 1982). Daily maximum / minimum temperatures are widely used at hatcheries.

Recommended temperatures for spawning, egg incubation, and fish rearing are presented in Table 1. These recommendation were developed by IHOT and are provided **as** general guidelines. Specific hatchery standards should be identified in hatchery operational plans.

Table 1. Recommended spawning, incubation, and rearing temperature ranges (mean daily).

Species	Recommended Spawning Temp	Recommended Incubation Temp	Recommended Rearing Temp
Chinook	42-55°F	41-53°F	48-54°F
Chum	45-55°F	40-53°F	46-52°F
Coho	40-49°F	40-56°F	48-56°F
Sockeye	51-54°F	40-56°F	40-56°F
Steelhead	39-49°F	45-55°F	48-59°F
Cutthroat	39-49°F	49-55°F	48-54°F

Dissolved Gases

The two most abundant atmospheric gases are oxygen and nitrogen. In a high quality water supply, oxygen should be near saturation, while nitrogen can be at any level less than saturation. Water should be manipulated mechanically if dissolved oxygen is less than 90% saturation and if dissolved nitrogen is greater than 102% saturation (Senn et al. 1984).

Chemistry

Water chemistry standards are important considerations when designing or rehabilitating hatcheries. Such information is also important when monitoring water supplies over a number of years to establish a baseline to determine if changes in water supplies have occurred (Westers 1988). Measurements should be recorded at the same time and place to standardize the results for comparison over time. Analysis should follow procedures described in "standard methods" (Greenberg 1981). Water quality standards relating to water chemistry for hatchery influent water are presented in Table 2.

Table 2. Acceptable levels for influent water quality parameters (ADFG 1986).

Water Quality	Acceptable Levels
Ammonia (un-ionized)	< 0.0125 mg/l
Carbon Dioxide	< 1.000 mg/l
Chlorine	< 0.003 mg/l
PH	6.5-8.0
Copper	< 0.006 mg/l (100 mg/l alkalinity)
Dissolved Oxygen	> 7.0 mg/l
Hydrogen Sulfide	c 0.003 mg/l
Dissolved Nitrogen	< 100% saturation
Iron	< 0.100 mg/l
Zinc	c 0.005 mg/l

Turbidity

Turbid water supplies caused by suspended or settleable solids can smother incubating eggs and fry, and can affect hatchery operations and the quality of fish reared. Most of the existing hatcheries were built at a time and location when excellent water supplies were available (a specific requirement for selecting a hatchery site). Over time, many water supplies have been degraded by man's activities impacting hatchery operations. Controlling habitat degradation is normally beyond the control of individual hatchery management, but within the control of regulatory agencies.

Turbidities less than 2000 parts per million (ppm) are acceptable for fish culture (Piper et al. 1982). An increasing trend in the turbidity of a water supply indicates the watershed is being adversely impacted. Under these circumstances, an investigation should be conducted to determine cause of the turbid conditions.

Alkalinity and Hardness

In freshwater systems, fish are hypertonic to their environment. Fish in hard water (>200 mg/l alkalinity) will spend less metabolic energy on osmoregulation than fish in soft water (<30 mg/l alkalinity), thus providing more metabolic energy for growth (Wedemeyer et al. 1976). Some fish stocks may be better adapted to low alkalinity than other stocks of the same species.

Nitrite

The accepted tolerance level of nitrite is 0.55 mg/l. Levels exceeding this inhibit the satisfaction of the oxygen demand of the fish (Smith and Williams 1974).

Contaminants

Water-borne toxic materials originating from external contamination sources present a problem similar to that of turbidity. It is important to identify problems to determine the impact on survival. Even though a hatchery is located in an area with no industrial sources of pollution, the widespread use of insecticides and herbicides represent a significant threat to water quality. Table 3 lists acceptable levels of chlorinated hydrocarbons and organic phosphates.

Pathogens

Pathogen free water sources can be provided by wells, springs or by disinfection. Standards for disease diagnosis, certification, and treatment ***are*** described in ***Chapter S-Fish Health*** Policy.

Table 3. Acceptable levels of chlorinated hydrocarbons and organic phosphates (USFWS 1980).

Chlorlnated Hydrocarbons	Acceptable Levels
Aldrin	< 0.003 mg/l
Endrin	< 0.004 mg/l
Dieldrin	< 0.003 mg/l
Heptachlor	< 0.001 mg/l
Chlordane	< 0.010 mg/l
Methoxychbr	< 0.030 mg/l
Lindane	< 0.010 mg/l

Organic Phosphates	Acceptable Levels
Malathion	< 0.10 mg/l
Guthion	< 0.01 mg/l

Alarm Systems

Reliable hatchery alarm systems are required to prevent egg and fish losses caused by a loss of water supplies. This has become increasingly important with the trends toward building hatcheries without housing, allowing personnel to move off station, and rearing threatened fish species. These situations require that there be fail-safe alarm systems and expeditious response processes to deal with circumstances that could result in fish losses.

Fish in adult holding ponds may be targeted by poachers or impacted by vandalism. Security must be considered and provided as necessary to prevent fish losses. Security considerations should include electronic security or off-hours security staff.

The following guidelines address the use of alarm systems at hatchery facilities.

1. Areas needing alarms:

   - Intakes
   - Large rearing ponds and adult holding ponds
   - Raceway headboxes and rearing ponds
   - Incubation facilities
   - Quarantine areas and facilities (e.g., chlorine injection)
   - Water treatment systems
   - Security

2. Outside systems as well as buzzers in residences are required.

3. Water flow alarms should be checked each day. All other alarms should be checked weekly.

4. A log should be kept recording alarms due to emergencies, tests, and maintenance requirements.

5. The use of telephone pagers is recommended.

Adult Collection and Holding

Several types of fish collection systems can be used to intercept upstream migrating adults for short- and long-term holding and spawning. These systems can involve either permanent or temporary structures, and can range from simple instream weirs to concrete barriers and holding facilities.

Because the size of fish being held varies greatly, even within the same species, long-term holding standards are based on units of fish weight. The water flow requirements for the long-term holding of adult fish are presented in Table 4. As a rule, at 50°F water temperature, 1 cubic foot of holding space is required for every 2 pounds of fish; and 1 gallon per minute (gpm) of water is required for each 15 pounds of adult fish. For each degree of water temperature below and above 50°F, the poundage can be increased or decreased 5% respectively, without flow adjustment (Senn et al. 1984).

Table 4. **Space and flow criteria for long-term holding of adult salmon and steelhead trout in 50°F water (Senn et al. 1984).**

Species	Ave. Assumed Welg ht/Fish (lbr)	Watei Flow/ Fish (gpm)	Pond Space/ Flsh (ft^3)
Spring Chinook	15	1	8
Fall Chinook (Tule)	15	1	7
Fall Chinook	18	1	8
Coho	8	0.5	4
Steelhead	8	2	2.5
Sockeye	6	0.4	4

Incubation

Several methods are available for incubating salmonid eggs. They range from single bucket incubation (for isolation of an individual female's eggs) to multiple vertical incubators requiring extensive plumbing systems. Various methods have evolved as fish culturists developed systems to meet program requirements. Tables 5-12 outline recommended incubator capacities for different incubator types, fish species, and life-cycle stages. The egg numbers presented in these tables represent upper thresholds that should not be exceeded.

Recommended flows for various types of incubators are outlined in Table 13. Water flows in incubators should be of sufficient quantity to maintain oxygen levels of at least 7 ppm. The recommended flows presented in Table 13 were developed by IHOT. Specific standards based on the hatchery's historical data should be identified in hatchery operational plans.

The rate of egg and alevin development, and quality of the fry, are a function of water temperature. The time required to reach various developmental stages is expressed **as** Temperature Units °F (TU). A Temperature Unit is defined as one degree of temperature above freezing for 24 hours. The TU requirements from egg fertilization to hatching and first feeding for various species are shown in Table 1.4.

Table 5. Recommended incubator capacities of fertilized-to-eyed eggs for spring and fall chinook.

Number of Eggs	Type of Incubator	Maximum Number Allowable
5,000 eggs	deep trough tray	25,000/section
100,000 eggs/section	deep trough tray bulk	1,000,000/trough
6,000-8,000 eggs	vertical incubator	48,000-64,000/half stack
20,000 eggs	shallow trough basket	120,000/trough
25,000 eggs	pond tray	800,000/keeper channel
27,000 eggs/tray	Japanese raceway	670,000/raceway

Table 6. Recommended incubator capacities of fertilized-to-eyed eggs for coho salmon.

Number of Eggs	Type of Incubator	Maximum Number Allowable
6,000 eggs	deep trough tray	30,000/section
9,000 eggs	vertical incubator tray	72,000/half stack
25,000 eggs	shallow trough basket	150,000/trough
32,000 eggs	pond tray	1,000,000/raceway
550,000 eggs	magnum deep	unknown
450,000 eggs	freestyle incubator	unknown

Table 7. Recommended incubator capacities of fertilized-to-eyed eggs for steelhead.

Number of Eggs	Type of Incubator	Maxlmum Number. Allowable
6,000 eggs	deep trough tray	30,00O/section
9,000 eggs	vertical incubator tray	72,OOO/half stack
25,000 eggs	shallow trough basket	150,OOO/trough
31,250 eggs	pond tray	1,OOO,OOO/racewav,
550,000 eggs	magnum deep	unknown
450,000 eggs	freestyle lncubator	unknown
38,000 eggs/tray	keeper channel	865,OOO/keeper channel
41,200 eggs/tray	Japanese raceway	1,030,00O/raceway

Table 8. Recommended incubator capacities of fertilized-to-eyed eggs for sockeye salmon.

Number of Eggs	Type of Incubator	Maxlmum Number Allowable
8,000 eggs	deep trough tray	40,OOO/section
10,000 eggs	vertical incubator tray	80,000/hafe stack
27,000 eggs	shallow trough basket	162,OOO/trough
35,000 eggs	pond tray	1,200,OOO/raceway ,
550,000 eggs	magnum deep	unknown
40,000 eggs/tray	keeper channel	1 ,OOO,OOO/keeper channel
43,000 eggs/tray	Japanese raceway	1,OOO,OOO/raceway

Table 9. Recommended incubator capacities of eyed-egg to fry for spring and fall chinook.

Number of Eggs	Type of Incubator	Maximum Number Allowable
5,000 eggs	deep trough tray	20,000/section
18,000 eggs/section	deep trough tray bulk	180,000/trough
6,000- 8,000 eggs	vertical incubator tray	48,000-64,000/half stack
20,000 eggs	shallow trough basket	20,000/trough
25,000 eggs	pond tray	800,000/raceway
35,000 eggs/tray	magnum deep	350,000/magnum deep
35,000 eggs/tray	keeper channel	800,000/keeper channel
27,000 eggs/tray	Japanese raceway	670,000/raceway

Table 10. Recommended incubator capacities of eyed-egg to fry for coho salmon.

Number of Eggs	Type of Incubator	Maximum Number Allowable'
5,000 eggs	deep trough tray	25,OOO/section
8,000 eggs	vertical incubator tray	84,00O/half stack
25,000 eggs	shallow trough basket	25,00O/trough
31,000 eggs	pond tray	1,OOO,OOO/raceway
'45,000 eggs/tray	magnum deep	350,00O/magnum deep

Table 11. Recommended incubator capacities of eyed-egg to fry for steelhead.

Number of Eggs	Type of Incubator	Maximum Number Allowable
6,000 eggs	deep trough tray	30,000/section
8,000 eggs	vertical Incubator tray	64,000/half stack
25,000 eggs	shallow trough basket	25,000/trough
31,250 eggs	pond tray	1,000,000/raceway
45,000 eggs/tray	magnum deep	350,000/magnum deep
38,000 eggs/tray	keeper channel	885,000/keeper channel (1,000,000 with BUA)
27,000 eggs/tray	Japanese raceway	1,030,000/raceway

Table 12. Recommended incubator capacities of eyed-egg to fry for sockeye salmon.

Number of Eggs	Type of Incubator	Maximum Number Allowable
6,000 eggs	deep trough tray	30,000/section
10,000 eggs	vertical incubator tray	80,000/half stack
40,000 eggs/tray	keeper channel	1,000,000/keeper channel
43,000 eggs/tray	Japanese raceway	1,000,000/raceway

Table 13. Recommended water flows for different incubation units and life-cycle stages.

Type of Incubation.	To Eyed Stage	To Initial Feeding
Deep Troughs	8gpm	12gpm
Deep Troughs Bulk	18 gpm	18 gpm
Vertical Incubators-8 tray stack	5gpm	5 gpm
Vertical Incubators-l 8 tray stack	6gpm	6 gpm
Shallow Troughs	7gpm	6 gpm
Pond Incubation	150 gpm	200 gpm
Magnum Deeps	40 gpm	45 gpm
Freestyle Incubator	30 gpm	
Keeper Channel.	75 gpm	125 gpm
Japanese Style Raceway	100 gpm	120 gpm

Table 14. Approximate hatching and first feeding temperature requirements for individual species at 50°F (Senn et al. 1984).

	Temperature Units (TU) Required	
Species	To Hatch	To First Feeding
Chinook	900	1665
Coho	850	1375
Sockeye	1260	1900
Chum	900	1550
Steelhead	570	975

Rearing

Fish rearing facilities are expansive components of the hatchery. This is because the space and water requirements increase dramatically as the fish grow. Standards for rearing facilities are based on physical features of rearing containers and how these containers are connected to reduce the amount of handling required when transferring fish. These factors affecting productivity are largely hydraulic in nature. The water replacement time and velocity must provide adequate levels of dissolved oxygen and remove metabolic waste products that are harmful to the fish. Specific hatchery standards based on the hatchery's historical data should be identified in hatchery operational plans.

Screening

A screened water supply and outfall must be provided to prevent fish from entering the hatchery or escaping to adjacent waters. Pond screens are made from a variety of materials and are used to contain fish in specific areas. Rearing containers should be double screened for fish lots that will not be released in waters adjacent to the hatchery.

Intake Screen Performance

In designing. effective fish facility screens, the swimming ability of the fish is the primary consideration. Swimming ability varies, and may depend upon a number of factors including the swimming time required, species, fish size, level of dissolved oxygen, water temperature, light conditions, physical condition of the fish, and migrational stage. For these reasons, screening criteria must be expressed in somewhat general terms. However, screens should be designed and operated to prevent any fish injuries.

Structuralprotection is usually required to protect the integrity of the screening material at intake. Provision of a trashrack, log boom, sediment sluice, and other measures may be needed. A reliable ongoing maintenance and repair program is necessary to assure facilities are kept free of debris accumulation.

Screen Faces

Screen faces should be placed **flush** with any adjacent screen bay, piers, walls, or streambank to allow fish unimpeded movement parallel to the screen face and ready access to bypass routes.

Approach Velocity

Approach velocity will be measured with the velocity component perpendicular to and approximately three inches in front of the screen face. For salmonid fry (less than 2.36 inches long), the approach velocity will not exceed 0.4 feet per second (fps). The approach velocity for salmonid fingerlings (2.36 inches and longer), will not exceed 0.8 fps.

Minimum Screen Area

The actual wetted screen **area** required **at the** minimum stream stage (excluding area affected by structural components) is calculated by dividing the maximum flow by the allowable approach velocity. Screen design must provide for uniform distribution of flow over the screen surface.

Fish Screens

Fish screens shall be cleaned as necessary to prevent accumulation of debris that would impede flow and violate approach velocity criteria, or otherwise create conditions that could harm fish.

Screen Mesh or Perforations

Screen openings may be round, square, rectangular, continuous slot, or any combination thereof, provided structural integrity and cleaning operations are not impaired. Screen openings must have rounded edges. Table 15 summarizes the recommended mesh size.

Table 15. Recommended screen mesh related to fish size'.

Fry Length	Crlterla for Screen Openings
Fry < 2.36" (60 mm) in length	Screen openings shall not exceed 0.125" (3.2 mm) in the narrow direction.
Fingerlings >2.36" (60 mm) in length	Screen openings shall not exceed 0.25" (6.44 mm) in the narrow direction.
All lengths	Screen material shall provide a minimum of 40% open material.

Predator Control Measures

Predation on fish is primarily either from birds or mammals. The pattern of predation is governed by facility construction, location, and the predator life cycle. Each facility should have a predator control system that meets its specific **needs.**

Methods of controlling predation may vary and frequently requires a combination of methods. Two commonly used non-lethal methods are scare devices and exclusion devices (i.e., physical barriers). Each hatchery should have a predator control system that meets its specific needs. Following are the steps for controlling predators at hatcheries:

1. Confirm predator activity and fish loss.
2. Determine species of concern.
3. Install devices matching control method to predator.
4. Monitor effectiveness.
5. Maintain control system if proven effective.

Food Storage and Quality Control

Fish require a complete diet containing essential elements for proper nutrition. It is important that all fish feed is stored at recommended temperatures and is used within the recommended period of time. Open formulas with frequent quality control inspections are recommended. Many feed delivery systems are available. All are successful if properly maintained and monitored. Performance standards for storage of food and quality control, as described by Fowler (1989), are listed below.

1. Dry / Semi-Moist / Moist Foods (dry < 12%; semi-moist 12-20%; moist >20% moisture): follow food manufacturer's recommendations.

2. Quality Control: appoint regional quality control officer to oversee production procedures and to monitor the following:

   - Verification by feed manufacturer that ingredients meet specifications.

   - Ensure feeds do not contain unwanted drugs or other additives.

   - Analyze ingredients contained in the final product to ensure that feed specifications have been met.

3. Handling

- Moist pellets should not exceed 10°F at point of delivery.

- Moist pellets should be removed from freezer just prior to feeding.

- Do not leave buckets of feed or feed containers outside exposed to light or heat.

- Open bags of feed should be fed within one to two days except when feeding small groups of fish.

- Automatic feeder hoppers and bulk storage facilities should be insulated against excessive temperatures (80°F and above).

Release Facilities

An important phase of the hatchery cycle is the collection and transfer or release of fish from hatchery facilities. Stress associated with fish collection and release activities can be severe and result in immediate or delayed mortality.

Equipment for on-site transportation and off-station release of fish includes crowders, pipes, flumes, brails, pumps, portable fish tanks, tank trucks and live boxes. The choice of a particular piece of equipment or method is based on the hatchery design and topography. The equipment and process used must ensure that fish are not subjected to adverse conditions. Factors that increase stress levels should be closely monitored. All volitional releases should be monitored.

Pollution Abatement

Although wastes from fish hatcheries are generally of low strength, their large volume can make a hatchery a significant point source of contaminants. Standards for individual hatcheries are outlined in the National Pollution Discharge Elimination System permits.

Performance Standards for Hatchery Operations

Broodstock Selection

Guidelines for broodstock selection are presented in ***Chapter 7—Genetics Policy.*** Hatchery broodstock programs should meet requirements established in the genetics policy section, subbasin planning documents, and hatchery operational plans in the following areas: species, stock, collection location, broodstock numbers, and collection strategy.

Spawning Practices

Standards for spawning practices should follow those presented in ***Chapter 7-Genetics Policy.***

Incubation

Salmonids eggs are remarkably uniform in their physiology and development. A basic understanding of the morphology and physiological process of a developing fish embryo is of value to the fish culturist in providing an optimum environment for egg development. Salmonid eggs become progressively more fragile during a period extending from approximately 48 hours after water hardening until they are eyed. During the eye stage, eggs are usually shocked and non-viable eggs are removed. Remaining viable eggs are measured, disinfected and shipped or processed for the next phase of their development.

Eyed-eggs may be incubated on artificial substrate installed in incubation trays or containers. It has been demonstrated that in some cases, use of artificial substrate has improved fish quality and survival (Fuss and Seidel 1987; Fuss and Johnson 1988).

Rearing

The hatchery's carrying capacity is the population size that can be supported without adversely affecting fish health and survivability. The carrying capacity of a rearing container (i.e., pond, raceway, trough, etc.) is limited to the period of least available habitat. This is influenced by water flow, water quality, suspended solids, and fish size and species. It is recommended that thresholds limiting capacity be determined and recorded in hatchery plans through a process described by Piper et al.

(1982), Klontz (1991), and specific historical hatchery records (Delarm and Smith 1990). Any projection of fish growth throughout the rearing period must take all limiting factors into account when initiating the rearing cycle.

Pond density Is commonly stated as pounds of fish per cubic foot of rearing space **(lbs/ft^3).** Pond loading is described as pounds of fish per gallon Per minute of inflow (lbs/gpm). Fish size, however, is an important variable which must be taken into account. As fish size changes, so do feeding and metabolic dynamics. Loading, expressed as lbs/gpm/inch of body length, allows for comparisons among different sizes of fish. Established loading criteria are usually reached or exceeded, while density criteria are not approached. Thus, the flow index (lbs/gpm/inch) is the more meaningful of the two (Piper et al. 1982). Water turnover rate for each container should also be monitored to maintain acceptable dissolved oxygen and metabolic product levels (Klontz 1991).

Hatchery fish should be fed with care and at a rate that allows the fish to consume the feed almost immediately. The feed should be delivered so that all fish have an opportunity to feed. Feeding must take priority over other hatchery operations, and the daily work schedule must allow time for careful feeding.

Smolt Quality

It has been reported that approximately 200 million salmonid smolts are released annually from Columbia River Basin hatcheries. The term “smolt” in some cases is very likely a misnomer as there is reason to suspect that apparently healthy hatchery fish may not actually be functional smolts. These fish may provide only limited contributions to the fishery or adult escapement. Non-smolted salmonids may negatively impact wild/naturally produced fish. In order for a hatchery smolt release program to be successful, it is important that fish are actively smolting at release (i.e., undergoing the physiological process necessary for migration and transformation to salt water).

Fish Health Management

The difference between a healthy hatchery fish and a sick fish often depends on the delicate balance between the fish, its rearing environment, and the external forces applied by the hatchery operator. These forces include typical hatchery activities, such as crowding, handling, hauling, marking, and treating with drugs and chemicals.

These activities can cause high stress levels that make fish more susceptible to diseases, both in the hatchery and after fish are released. Stress in the hatchery environment can also inhibit fish growth.

This manual does not provide performance measures for determining the quality of hatchery fish. However, by following the recommended performance standards, the hatchery operator will reduce fish stress and provide the best opportunity to produce a healthy fish. Hatcheries in the Columbia River Basin are operated under a fish health management philosophy that is outlined ***in Chapter 5-Fish Health Policy.*** Standards associated with the fish health policy include hatchery monitoring visits, a fish health inspection program, hatchery sanitation procedures, and egg/fish transfer protocols.

Release

Salmonid releases in the Columbia River Basin are established through subbasin and species planning documents, ESA permit conditions, mitigation requirements, and court mandates. Hatchery operations are focused on releasing fish at a specific time and size to meet specific program objectives. Fish releases are either made on-site (i.e., at the hatchery) or at an ***off-site*** location. They can also involve either a forced release (i.e., all fish are forced out of the hatchery at the same time) .or a ***volitional*** release (i.e., fish are allowed to leave on their own volition).

Fish size and time of release are two variables that have a considerable influence on survival of hatchery fish. Size-selective predation may be influenced by time and size "windows" that allow fish to achieve maximum growth by exploiting available food. In addition, timing can be critical to avoid predators and take advantage of spring river flows and ocean upwelling conditions. Inappropriate release times or sires may cause physiological problems that in turn retard growth and enhance the fish's susceptibility to predators.

The growth and survival of wild fish can also be affected by time and size of hatchery releases. For example, time and release size of non-migratory hatchery fish may influence freshwater competition. Adjusting time of release can reduce the amount of overlap between some species in freshwater and during early marine life. This can reduce the impact of predaceous hatchery fish on some wild stocks and also reduce the likelihood of food limitations.

Table 16 presents some standards for appropriate size and time of release. These standards are provide only as general guidelines. All releases should follow general performance standards of genetics, fish health, and ecological interactions policies as well as specific performance standards identified in hatchery operational plans.

Table 16. Guidelines for appropriate fish size and time of release'.

Species	Size at Release Fish/Pound	Release Time
Fall Chinook	8-35	March and August
Fall Chinook (O-age)	40-l 00	March through July
Spring and Summer Chinook	5-36.7	March through May August through November
Spring & Summer Chinook (Fingerlings)	45-70	April through June
Coho	12-20	March through June
Winter Steelhead	4-l 0	April and Mav
Summer Steelhead	4-10	April and Mav
Sea-Run Cutthroat Trout	3-7	April and May
Sockeye	25-50	April through October
Chum	250-500	Mid-April

1 Guidelines are based on figures from Fuss et al. 1989; Bell 1973; Vreeland 1989. Senn et al. 1984; Hutchinson 1993; Peck 1993; Christianson 1993; Wold 1993; and Sheldrake 1993; as modified by IHOT.

Transportation

An extremely important aspect for meeting hatchery program goals is the transportation of fish between hatcheries or selected sites. Since the responsibility of the hatchery does not end until fish are delivered to the release site, it is important to identify loading, hauling, and release standards. Guidelines regarding these transportation activities are presented in Appendix C.

Evaluations

Hatchery effectiveness is often measured through an analysis of marked juvenile fish that are later captured or observed at various locations during juvenile and adult migration, as well as in various fisheries and returns to hatcheries and spawning grounds. To ensure an acceptable analysis, it is essential that hatchery contribution studies are based on marked fish that are representative of the total released population. The types of information need for this type of study are listed below. Evaluation guidelines are also provided in Appendix D.

1. Number of marked fish released
2. Number of total fish released and method of enumeration
3. Size at release
4. Location and dates of marking
5. Date of release
6. Species, race, stock, and brood year
7. Type of mark
8. Purpose of study
9. Physiological and disease condition of fish
10. Water temperature at release (rearing and release site)
11. Type of release (fixed, volitional, trucked)
12. System for obtaining representative sample

Training

Most investments in hatcheries have been on land, building materials, equipment, and fish food. However, trained personnel are also essential parts of a successful hatchery operation. Human talents comprise one of the most valuable resources, and this professional knowledge and experience must be maintained, expanded, and rewarded. It is imperative that the education process and transfer of new technologies be continued and expanded to meet the increasingly complex issues facing hatchery management. If new technology is not transferred and implemented, the public investment in research is not only wasted, but potential gains in product quality are lost. Continuing education opportunities should include the following:

- Computer courses
- Fish health courses
- Safely courses
- Fish culture courses
- Commercial driving training
- On-the-job training
- Agency seminars

- Chemical handling and usage seminars
- Management seminars
- Interagency exchanges
- Regional meetings and **conferences**

Recommendations for hatchery training are presented below.

1. Each hatchery should have a training schedule for its staff.

2. Each staff member should have a personal training plan approved by supervisor and reviewed during annual evaluation.

3. Exchange of training details is encouraged between hatcheries and agencies.

4. Off-duty training should be encouraged and rewarded.

5. Staff meetings should be held at least monthly.

PERFORMANCE MEASURES

Performance Measures for Program Objectives

Each hatchery, depending on its specific management goal, will develop and follow established performance measures to monitor its annual production program. These performance measures will be changed as the hatchery program is revised. New performance measures could result from new scientific information, additional supplementation requirements, reprogramming, increased survival of fish released at the hatchery, or a combination of these factors. Key questions that should be asked about **each** hatchery include:

- Are the hatchery's programs outlined in a subbasin management plan (e.g., Umatilla Basin Artificial Production Plan or Lower Snake River Compensation Plan)?

- Is the hatchery operating under a current hatchery operational plan?

- Is a hatchery monitoring and evaluation plan in place?

Since hatcheries are operated to meet objectives of various programs, agreements and statutes, it is important to identify specific production requirements in the hatchery operating plans. Performance standards established for production must be reviewed and analyzed through a hatchery audit process, and any variance with the established program performance standards must be recorded. The following lists performance measures **associated** with hatchery program objectives:

1. Adult contribution to fisheries, spawning grounds and hatcheries
2. Adult pre-spawning survival as compared to established goal
3. Egg-take as compared to established hatchery goal
4. Green-egg-to-eyed-egg survival as compared to established goal
5. Eyed-egg-to-fry survival **as** compared to established goal
6. Fry-to-smolt survival as compared to established goal
7. Production as compared to established goal
8. Percent survival (smolt to adult) as compared to established goal
9. Number of eggs, fry, fingerlings, smolts and/or adults to meet basinwide needs

Production levels and fish size at release vary with hatcheries, species, and programs. It is essential that production numbers and release sizes are identified and are within 10 percent of the annual production goals.

Performance Measures for Facility Requirements

Compliance with the performance standards in this section will also be measured through the independent hatchery audit. This audit will compare the hatchery facilities against the guidelines presented in the **Performance Standards for Facility Requirements** section of this manual.

Performance Measures for Hatchery Operations

Broodstock Selection

Guidelines for broodstock selection are presented in ***Chapter 7—Genetics Policy.*** Hatchery broodstock programs should meet requirements established in the genetics policy section, subbasin planning documents, and hatchery operational plans in the following areas: species, stock, collection location, broodstock numbers, and collection strategy.

Incubation

The recommended incubation flows and incubator capacities presented in tables 5-13 can be used as a general guide for measuring hatchery performance in this category. Specific standards based on hatchery historical data should be identified in hatchery operational plans.

Rearing

Carrying capacities are highly variable and directly dependent on a number of factors, such as water flow, temperature, water exchange rate, dissolved oxygen, metabolic waste buildup, types of rearing containers, and size and species of fish reared. Therefore, it is important that a combination of flow and density indices be used in conjunction with comparison of past experiences to establish pond loadings. Pond loadings must be calculated and recorded for all containers at each hatchery. Loading rates will be measured against those established in the hatchery operational plans. Information regarding calculation of theoretical loading levels are described by Piper et al. (1982), Liao (1971), Westers and Pratt (1977), Burrows and Combs (1968), Westers (1970), and Klontz (1991).

Release

All releases should follow general performance standards of genetics, fish health, and ecological interactions policies as well as specific performance standards identified in hatchery operational plans. Key questions associated with these performance standards are:

1. Does hatchery performance meet requirements outlined in the regional hatchery policies and in subbasin and hatchery plans for the following areas:

   - percent smoltification
   - rearing density
   - disease condition
   - number
   - ⬧♓⌘♏
   - date(s) of release
   - location at release

2. Are fish reared in the subbasin or acclimated in the subbasin?

3. Is the release strategy appropriate for the program?

Smolt Quality

The monitoring of the physiological development of salmonid fingerlings and the possible correlation with juvenile and adult survival rates has been studied for a number of years (Zaugg 1959; Virtanen et al. 1991). These efforts have had varying degrees of success and acceptance by hatchery managers. As part of the commitment to adaptive management, standards and performance measures will be systematically evaluated. It is important that any new information provided by this monitoring be used to revise hatchery management practices.

It is also important that any variance from hatchery practices and management be identified and related to the quality of fish produced. Improving the percentage of smolts released is an appropriate goal for developing hatchery performance measures. To be successful, hatchery smolts must be healthy and physiologically ready for their post-release environments. Juveniles in inadequate stages of smoltification and with substandard health are subject to losses from predators, aimless migration, and osmoregulatory dysfunction.

Chapter 5

Fish Health Policy

Fishery resources must be protected from the adverse effects of disease: Fish populations, whether cultured or free-swimming, are exposed to pathogens. Under certain conditions, these pathogens can cause disease outbreaks that lead to fish mortality. This can ultimately result in a significant impact on the fishery resource. Consequently, it is important that managers of a watershed, river, or hatchery facility be constantly aware of disease problems or the potential for disease occurrences.

Disease occurrences are influenced by a combination of three factors: host, pathogen, and the environment. All three of these factors must be taken into account when addressing fish diseases (Snieszko 1973;. Wedemeyer 1970; Wood 1974). Serious fish losses can occur when host and pathogen are present in an environment that favors the disease.. Removing or modifying one of the factors will likely reduce or prevent the disease. Therefore, the effective management of diseases is closely linked with the successful management of fish populations.

There are both passive and active measures that can be used to manage fish diseases. Restricting the transfer of any infected animals is one example of a passive disease management. Active disease management might include improving environmental conditions or treating the disease with therapeutants.

POLICY STATEMENT AND GOALS

Policy Statement

It shall be the policy of the management entities of the anadromous salmonid resources in the Columbia Basin to protect those resources by restricting the importation, dissemination, and amplification of pathogens and diseases known to adversely affect fish.

Goals

1. Strive to produce healthy fish for release or transfer.

2. Ensure that all fish produced are under a specific fish health management program.

3. Monitor and evaluate the health of wild, natural, and cultured fish populations.

4. Foster open and frequent communications among managing entities to jointly resolve fish health related issues.

PERFORMANCE STANDARDS

To protect the fishery resources, health care standards must be followed to prevent the importation, dissemination, and amplification of pathogens and diseases known to adversely affect fish. These standards will include:

- Hatchery monitoring visits by fish health specialists
- Broodstock inspection program for fish pathogens
- Hatchery sanitation procedures
- Water quality parameters
- General cultural practices (rearing criteria)
- Egg and fish transfer and release requirements
- Communication among management entities
- Regulatory compliance
- Research
- Identification of future needs of fish health programs.

Hatchery Monitoring Visits by Fish Health Specialists

1. Conduct visits at least a monthly, more often when necessary.

2. Monitoring should be conducted by a qualified fish health specialist.

3. Examine a representative sample of healthy and moribund fish from each lot. Number of fish examined is at the discretion of fish health specialist.

4. Review fish culture practices with manager including nutrition, water flow and chemistry, loading and density indices, handling, disinfection procedures, and treatments.

5. Report findings and results of fish necropsies on a standard fish health reporting form.

6. Recommend appropriate drug or chemical treatments. If antibiotics are advised, collect tissues and culture pathogen to determine drug sensitivity when possible.

7. Summarize fish health status of stock prior to release or transfer to another facility. Summary may be made on standard reporting form and occur during the regular monitoring visit.

Fish Health inspection Program for Broodstock

1. Annually examine each broodstock for the presence of reportable viral pathogens. Number of individuals examined per stock will vary according to management objectives. However, the minimum number would be at the 5% Assumed Pathogen Prevalence Levels (APPL), generally 60 fish. Tissues and fluids tested would include kidney, spleen, ovarian fluid, and possibly milt following American Fisheries Society (AFS) "Fish Health Blue Book" procedures (AFS 1979).

2. Annually screen each salmon broodstock for the presence of Renibacterium salmoninarum (Rs). Methodology and effort would be at the discretion of the relevant fishery co-managers, following the AFS "Fish Health Blue Book" procedures.

3. Conduct inspection by or under the supervision of an AFS-certified fish health inspector or qualified equivalent acceptable to co-managers.

Hatchery Sanitation Procedures

1. Investigate and pursue the acquisition of pathogen-free water at each facility, especially for incubation and early rearing.

2. Recommend, implement, and monitor the following hatchery sanitation procedures:

   - Disinfect/water harden eggs in iodophor (see definition of iodophor in the Glossary for correct dosage). Eggs should be disinfected prior to entering "clean" areas in incubation room. In high risk situations, disinfect eggs again after shocking and picking.

   - Place foot baths containing disinfectant at the incubation facility's entrance and exit.

   - Sanitize equipment and rain gear utilized in broodstock handling or spawning after leaving adult area and prior to using in other rearing vessels or the hatchery building.

   - Sanitize equipment used to collect dead fish prior to use in another pond and/or fish lot.

   - Disinfect equipment, including vehicles used to transfer eggs or fish between facilities, prior to use with any other fish lot or at any other location. Disinfecting water should be disposed in designated areas.

   - Sanitize rearing vessels after fish are removed and prior to introducing a new fish lot or stock.

   - Properly dispose of dead fish.

Water Quality Parameters

1. Utilize water supplies that provide acceptable temperature regimes for eggs, juveniles, or adults.

2. Dissolved gases should be near saturation for oxygen and less than saturation for nitrogen.

3. Water chemistry at any new site must meet the quality required by salmonids. The list of parameters to be measured are identified in ***Chapter* 4-Hatchery *Performance Standards Policy.***

4. Chemical parameters should be measured to establish baseline data. If disease occurs, water chemistry should be checked for variance from the baseline, if recommended by a fish health specialist. The list of parameters to be measured are identified in ***the Chapter 4-Hatchery Performance Standards Policy.***

5. Pathogen-free water is desirable at all facilities for both incubation and rearing as it eliminates one of the major factors of many diseases.

6. When using surface water for rearing, the source must be screened to prevent other fish from entering and to minimize debris.

General Cultural Practices (Rearing Criteria)

Rearing standards must be established for each facility, taking into account the facility's design, species and stocks of fish handled, and water sources and quality. General guidelines will need to be refined to allow for the efficient use of each facility without compromising fish health, genetic integrity and stock prevalence. Specific criteria and general hatchery practices are identified in ***Chapter 4-Hatchery Performance Standards*** Policy.

Egg and Fish Transfer and Release Requirements

Transfer and release of live fish, eggs, or gametes within the Columbia River Basin is allowed under the appropriate co-managers permit system. The permit system includes a formal notification of all relevant co-managers, allowing them to comment on all proposed egg/fish transfers and releases. It also include documenting that the fish or eggs meet the fish health requirements specified in this policy.

Notification Process

Future Brood Document Process

All co-managers will incorporate their proposed program of egg and fish transfers and releases for the coming year (August through July) into the Future Brood Document process. All proposed programs will be exchanged and reviewed by co-manager' fish health staffs for consistency with the fish health policy between June 1 and July 1. A five-year history of reportable pathogens found at all facilities and watersheds will be available for review during this time. Final approval of the Future Brood Document will be completed on a watershed-by-watershed basis and will require signatures of all co-managers by August 1. Upon final approval, the document will become accepted as the Current Brood Program and all listed transfers and releases will be approved pending results of health inspections.

Changes to the Current Brood Document

Any fish transfer or release not listed in the Current Brood Document requires that the requesting co-manager notify all relevant co-managers a minimum of 10 working days prior to the proposed transfer or release. If the transfer or release is consistent with this policy, and there are no fish health objections from co-managers within 10 working days after notification, then the transfer or release is approved.

Fish Health Information Required For Transfer .or Release

The foliowing fish health information is required to be completed and on file with (or received by) the receiving facility a minimum of two working days prior to the actual transfer of eggs or fish:

Information Reouired for Egg Transfers

1. Completed copy of the parental broodstock inspection report.

2. Five-year history of reportable pathogens found within the facility and watershed, if this transfer was not part of the Future Brood Document review process.

Information Reouired for Fish Transfers and Releases

1. Egg transfer requirements listed above.

2. Completed pre-transfer/release fish health examination report for that juvenile lot as stipulated within this document.

3. Summary of all diagnostic cases experienced by that juvenile lot.

Responsibilities of *the Facility Manager*

It shall be the responsibility of the receiving or releasing facility manager to verify that (1) the transfer or release has been approved, and (2) all required fish health reports are completed and received prior to allowing entry of eggs or fish onto their facility or release of any fish. A transfer/release may be denied on the basis of the health of the stock or lot as determined by the relevant co-managers.

1. Transfers of fish experiencing a disease epizootic are to be minimized. Transfers of fish in this condition are to be coordinated with relevant co-managers.

2. Fish experiencing a disease epizootic should not be released. Fish in this condition are to be held until mortalities are reduced to acceptable levels. If mortality cannot be reduced to acceptable levels, the fish will be destroyed. For stocks of critical concern, or where co-managers concur, release may be considered as an alternative.

3. Transfer or release decisions should consider:

   - Primary and secondary effects on other populations of fish.

   - Intrinsic value of the fish lot (i.e., if remnant population of an endangered species or if replacement population is available).

Any disputes will be discussed with fish health specialists and program managers. If the dispute cannot be resolved, it will be referred to an appropriate policy group.

Fish Health Requirements for *Egg and* Fish *Transfers and Releases*

Restrictions on egg and fish transfers and fish releases are needed to reduce dissemination and amplification of infectious diseases and pathogens. This is particularly important for specific pathogen-free watersheds or facilities.

Egg Transfers within the Basin

1. Eggs from anadromous broodstocks may be transferred provided that (a) the watershed has a negative 5-year history for reportable viral pathogens; and (b) the parents of the eggs are saeened and found to be negative for reportable viral pathogens at the following minimum APPL: ovarian fluid and kidney/spleen tissues sampled at 5%.

2. If the broodstock test positive for a reportable viral pathogen, or there is a history of a reportable viral pathogen in the watershed within the last five years, eggs can only be transferred within the same watershed or to another watershed within the basin where that virus has been detected within the last five years. *Exception:* Eggs from a stock found to be positive for a reportable viral pathogen may be transferred to a historical negative watershed in the basin provided that (a) 100% of both male and female parents are inspected and found negative for that viral pathogen; (b) no viral pathogens are found in that broodstock on the day that the eggs for transfer are being spawned; and (c) eggs are maintained in isolation on specific pathogen-free water supply until the results of the testing are known.

   Exemptions for eggs not incubated in viral-free water or progeny from positive parents may be granted after a review of probable risks by co-managers. An exception would be if eggs are maintained at a quarantine facility.

   If eggs have been previously transferred to a hatchery in another watershed where the specific viral pathogen has not been detected in the last five years, the eggs must be returned to the watershed of origin or be destroyed.

3. All eggs must be water-hardened in iodophor when entering the incubation area. If eggs are later transferred to a new facility, they must also be disinfected upon arrival.

4. When sampling at less than the 100% level, eggs must be held in isolation at either the sending or receiving facility until the adult health inspection report is completed and received by the facility co-manager.

Fish Transfers and Releases within the Basin

For a fish transfer or release to be considered within the basin, all of the following reports must be completed and on file with (or received by) the relevant co-managers two working days prior to the transfer:

1. An adult health inspection report on parental broodstock. The screening for this report will be, at a minimum, the APPLs for egg transfers within the basin.

2. Results of an on-site pre-transfer / release health examination for juvenile lots to be transferred. This examination will be conducted by the relevant co-manager's fish health staff no longer than six weeks before the transfer. A fish health specialist will examine fish from the lot that is to be transferred / released for clinical signs of disease and for cause of disease.

3. A summary of all diagnostic cases experienced by the lots to be transferred.

4. A five-year history of reportable pathogens found within the facility and watershed, if this transfer was not part of the Future Brood Document review process.

Transfer and release programs involving fish that are either from parents with reportable viral pathogens, or reared in a watershed / water supply with a history of reportable viral pathogens within the last five years, will not be transferred or released in a historically negative watershed (unless the criteria #2 under egg Transfers with the Basin are followed). Exemptions may be granted after a review of probable risks by affected co-managers.

Transfer and release programs occurring prior to policy ratification that involve fish that are either from parents with reportable viral pathogens, or reared in a watershed / water supply with a history of reportable viral pathogens within the last five years, may continue to be transferred or released in a historically negative watershed. However, the viral pathogens must have low risk factors or not shown to have deleterious disease effects.

Egg Transfers into the Basin

1. Eggs from anadromous broodstocks may be transferred into the basin provided (a) 100% of both male (kidney samples or milt) and female (ovarian fluids) parents are negative for reportable viral pathogens; and (b) no virus is isolated from that broodstock on the day that eggs to be transferred are spawned. In addition, if eggs are being transferred from a watershed in which IPNV has been detected, 100% of the male and female kidney and spleen tissues must be tested.

2. Eggs from captive broodstock and resident fish programs may be transferred into the basin provided the spawning adults are screened and are negative for reportable viral pathogens at the following minimum APPL:

   - If broodstock and eggs are on reportable virus-free water and have a negative history for the last three consecutive years, then ovarian fluid and kidney/spleen tissues are sampled at the 5% APPL.

   - If the broodstock and site are on reportable virus-free water and have a negative history, but less than three years of viral history, and the brood parents were not sampled, then the conditions outlined in #1 above applies.

   - If the broodstock and site are on reportable virus-free water and have a negative history, and the brood parents were sampled and negative, but less than three years of viral history, then ovarian fluid and kidney/spleen tissues are sampled at the 2% APPL.

   - Testing for Rs must be conducted using techniques outlined in the AFS "Fish Health Blue Book" or a technique that is more sensitive.

3. All eggs must have been water-hardened in iodophor upon entering the incubation area. If eggs are later transferred to a new facility they must also be disinfected upon arrival.

4. Eggs must be held in isolation on pathogen-free water at the sending facility, or in quarantine at the receiving facility, until the adult health inspection report is completed and received by the facility co-manager.

Fish Transfers into the Basin

1. Fish may be transferred into the basin if (a) all incubation and rearing has occurred with reportable pathogen-free water; (b) eggs were water hardened in ociophor; (c) no reportable pathogens were detected in the stock within the last five years (or three years if from a captive brood); and (d) the fish were held in isolation from other stocks.

2. Fish may be transferred into the basin provided the following reports are completed and on file with (or received by) the co-manager of the receiving **facility. Reports must be received two** working days prior to transfer if **it** is part of the current brood program; ten working days if **it is a new transfer.**

   - An adult health inspection report conducted on parents of fish to be transferred as required in **Egg** Transfers into the Basin.

   - Results of an on-site pre-transfer/release health examination for juvenile lots to be transferred. This examination is to be conducted by the relevant co-manager's fish health staff or otherwise approved fish health specialist within the six weeks prior to transfer. A fish health specialist is to examine fish from the lot which is to be transferred for clinical signs of disease and for the cause of disease.

   - **A** summary of all **diagnostic cases experienced** by the lots to be transferred.

   - A five-year history of reportable pathogens found within the facility and watershed, if this transfer was not part of the Future Brood Document review process.

Adults may not be transferred into the basin unless they are transferred into a quarantine facility, or they are the result of a viral pathogen-free captive brood program on reportable pathogen-free water.

PERFORMANCE MEASURES

Compliance with the performance standards are measured by answering the following questions:

1. Are monthly hatchery monitoring visits being conducted by a qualified fish health specialist?

2. Are annual broodstock inspections conducted for Rs and reportable viral pathogens?

3. Is the hatchery following accepted sanitation procedures?

4. Are water quality parameters outlined ***in the Chapter 4-Hatchery Performance Standards Policy*** being followed?

5. Are rearing standards outlined in ***Chapter P-Hatchery Performance Standards Policy*** being followed?

6. Are egg and fish transfer/release requirements met?

COMMUNICATION AMONG MANAGEMENT ENTITIES

1. Co-managers will communicate on all matters related to hatchery operations and health concerns specific to the basin.

2. Cooperating fish health managers will meet at least twice a year to discuss issues and solve problems (PNFHPC 1988). This will be accomplished through meetings of Pacific Northwest Fish Health Protection Committee (PNFHPC) and more specific meetings if needed.

3. There will be semi-annual reporting of all reportable, and some nonreportable pathogens to cooperating entities (accomplished through PNFHPC). This list will include all culture facilities as well as major watersheds without culture facilities.

4. A comprehensive list of co-managers contacts will be prepared and distributed semi-annually.

5. Confirmed isolation of a reportable viral pathogen or epizootics due to a reportable pathogen or undetermined causes requires notification in writing or facsimile of any affected cooperator within two working days.

REGULATORY COMPLIANCE

1. Only therapeutants or pesticides approved by federal and state regulators, "low regulatory priority" therapeutants, or those under an Investigational New Animal Drug (INAD) application will be used to treat fish. All treatments will be pre-approved by the area fish health specialist.

2. Co-managers will be responsible for implementing and monitoring compliance with all policies and regulations relating to fish health.

RESEARCH

Applied research will be developed and implemented on an as-needed basis.

FUTURE NEEDS OF FISH HEALTH PROGRAMS

1. Conduct surveillance of wild stocks for reportable pathogens.
2. Standardize data bases for information exchange.
3. Provide support to implement new INADs.
4. Reduce incidence of Rs through active screening programs and selection of juveniles for rearing and release.

IMPLEMENTATION PLAN

1. Within one year of policy ratification, IHOT members are to implement all provisions of the performance standards.

2. Upon adoption, an audit of individual facility operations regarding fish health should be performed and this audit should be repeated every three years to ensure compliance.

3. Upon adoption of these policies by the individual agencies, the following reports will be required:

- A report on facility and basin fish health status will be prepared annually, and distributed through the IHOT facilitator.
- The initial Future Brood Document will be prepared, and distributed through the IHOT facilitator by August 1 of each year. After inseason revision and updates, this document will be known as the Current Brood Document. This document will also be maintained by the IHOT facilitator and a summary report of actions will be distributed each year.
- Upon implementation of this policy, participants will provide a five-year history of reportable pathogens to the MOT facilitator for distribution. This history will be updated annually for use in meeting the requirements listed under the Future Brood Document process.

MONITORING AND EVALUATION PLAN

1. Within **one** year of policy ratification, define reporting structure to document the occurrence of pathogens on facility and basin status, including relevant wild stock sampling efforts.
2. Twice a year, update facility and basin status regarding reportable pathogens and any changes to the frequency of occurrence. This report will be coordinated through Pacific Northwest Fish Health Protection Committee with copies to MOT.

BUDGETS

Establish budgets to concurrently fund the following activities:

- Coordination activities
- Therapeutant research and registration
- Evaluation and monitoring efforts (basin, facilities, wild and hatchery stocks)

Chapter 6

Ecological Interactions Policy

Hatchery fish can interact with wild fish through several different ecological processes. One example would be the competition between hatchery fish and wild fish for food or space. This type of competition is generally influenced by the carrying capacity of available habitat.

Potential ecological interactions can occur in two ways. One involves the *indirect* effects of having more fish in an existing aquatic ecosystem. The second involves the *direct* effects that hatchery fish have on other fish when they all utilize the same habitats.

For indirect effects, studies have demonstrated that the presence of many salmonid species in a stream can produce more biomass than a single species; however, the total biomass of each individual species will be less than if it was reared alone (Rensel et al. 1984). This increase in biomass is a result of habitat partitioning. Habitat partitioning is created because each species may have different habitat requirements at different life-cycle stages. However, for the above to be true (decreased biomass of individual species in a multi-species assemblage), the interacting species must share scarce resources for at least part of their life cycle. If the species co-evolved, the fish probably possess some mechanisms to compensate for these interactions.

In contrast to interactions that might increase as natural populations rebuild, stocking hatchery fish may have direct effects on other fish populations. These effects may be reduced, but not eliminated, through a variety of fish rearing and release strategies. These strategies include (1) adjusting the number and/or size of fish to be released, (2) adjusting the time and/or location of release, (3) acclimating fish to release waters, and (4) releasing fish at the appropriate life-cycle stage and time of year when they will migrate quickly downstream.

The regional policy presented below addresses ecological interactions resulting from the release of hatchery fish. The policy does not address the broader issue of ecological interactions resulting from increasing the natural abundance of anadromous species. Strategies to resolve this issue will be addressed when the long-range management plans are developed and adopted.

POLICY STATEMENT AND GOALS

Policy Statement

It shall be the policy of the management entities of the anadromous salmonid resources in the Columbia Basin that artificial propagation programs will be designed and implemented to minimize ecological interactions that adversely affect the productivity of aquatic ecosystems.

Goals

1. Ensure that all fishes produced and released are under a specific management program.

2. Consider the ecological effects attributable to the specific hatchery products following release.

3. Consider how specific release strategies affect aquatic ecosystems.

4. Monitor and evaluate implementation of ecological interaction guidelines and ecological effects of artificially propagated fish on wild, natural, and cultured fish populations.

5. Foster open and frequent communications among managing entities to jointly resolve related issues.

PERFORMANCE STANDARDS

Performance standards associated with the ecological interactions policy are designed to protect the capacity of a fish population (hatchery or natural) to persist in the natural environment. The ecological performance of hatchery, **target, and non-target stocks can influence** both direct and indirect **interactions.**

The impact of hatchery-reared fish on natural populations is a relatively new concern **associated** with evaluating salmon hatchery practices. Therefore, new tools and methodologies are needed to measure impacts. At this time, hatchery **practices are** still evolving to meet specific ecological objectives and **associated standards.**

The state-of-the-art precludes a "cookbook" approach to the ecological management of stocks. Therefore, it is recommended that ecologists be directly involved in the review and evaluation of existing standards, and development of any new standards. Ecological interactions affecting natural populations may or may not be desirable, depending upon the management objectives. For example, a supplementation program would be expected to have a beneficial impact on natural stocks, while interactions caused by ocean ranching should be avoided.

Specific performance standards designed to measure the interaction between ecological factors and hatchery-reared fish may be derived from:

1. Factors limiting production, including identification of critical or unique habitat-use patterns **associated** with specific life history stages.

2. Species-specific carrying capacities in tributaries, mainstem reaches, and estuaries.

3. Changes in critical habitat parameters (e.g., adult passage at dams and other observations; effectiveness of screening and bypass systems for irrigation diversions; adequate in-stream flows for spawning, rearing, and outmigration; and water quality, especially **as** impacted by such human activities as logging and grazing).

4. Interactions between pre-existing resident salmonids, anadromous salmonids, and other species.

5. Interactions among hatchery-released and natural anadromous salmonids (e.g., competition, predation, social behavior, and residualism).

6. Specific times and **places** associated with large losses of outplanted fish and development of compensatory **release** strategies.

The specific performance standards will vary depending upon the program objectives. For example, **if the program objective *is to supplement a natural fish population* using *cultured* fish,** then fish should be released at **a** size, smoltifrcation state, and disease condition that will minimize negative **impacts** on **natural** juveniles while increasing the number of returning **spawners. If *the program objective* is *to maintain hatchery stocks separate from natural stocks,*** then juveniles should be released in **a manner that will** not directly or indirectly increase the mortality of **natural** fish.

Measures that could be used to mitigate potential risks of "significant" adverse ecological interactions include both programmatic considerations and operational changes. While specific management programs are developed by the fishery managers, each program should consider both these elements to minimize ecological interactions.

Programmatic Considerations in Hatchery Programs

The selection of fish stocks for any hatchery project will have a substantial influence on species interactions, particularly competition and predation. This is because many of the factors that affect the spatial and temporal overlap of stocks (i.e., timing, distribution, and migratory patterns) are stock specific. Therefore, hatchery programs should use fish stocks that have life history characteristics that will minimize adverse ecological interactions with relevant wild fish populations.

Operational Changes to Hatchery Programs

Release Location and Age at Release

The location of hatchery fish releases (both on and off station) will influence species interactions. The release site will directly impact the degree of overlap between species. However, at each site the optimal release time and size **may** show inter-annual variation (Zaugg 1989). To reduce predation losses, hatchery **fish** can be released further downstream to reduce the distance that fish are exposed to predators (Ebel 1970; Fresh et al. 1982). However, care must be taken to ensure that these fish will successfully imprint and thereby reduce inadvertent straying as returning adults.

The growth and **survival .of wild** fish **stocks will also be affected by** where hatchery fish are released. When releasing non-migrant hatchery fish, intraspecific competition can be reduced by releasing the fish in areas with the most available habitat (Solazzi et al. 1983). For example, in order to avoid competition, chinook fry should not be planted in upstream river areas where coho are often found. When non-migrants are released in the upper reaches of a watershed, many competitive interactions in the entire river system may be created as these fish distribute themselves. Fish that are forced to emigrate as a result of competitive interactions (e.g., the losers) may in turn interact with fish further downstream and so on.

Release locations can also affect wild stock productivity during the fish's estuarine life. For example, because fish from many different watersheds co-exist in estuarine waters, it may be desirable to create wild stock sanctuaries where spatial overlap is reduced between wild stocks and hatchery fish. This could allow the wild fish to outgrow a portion of their predators.

Size and Time of *Release*

Size and time of release are two variables that have a considerable influence on hatchery fish survival (Bilton et al. 1982; Foerster 1954; **Mathews** and Buckley 1976). For each hatchery project, there is probably a set of site-specific release conditions that will optimize fish growth and survival (Bilton et al. 1982). Time and size of release may directly influence adult production through conditions encountered by juvenile fish during the first months after release. Moreover, timing can be critical to avoid predator aggregations. There is also evidence indicating that an inappropriate time and size of release can cause osmoregulatory dysfunction that in turn retards growth and enhances susceptibility to predators (Mahnken et al. 1982).

Time and size of hatchery fish release can also affect the growth and survival of wild fish populations. For example, the release time of non-migrant hatchery fish can influence freshwater competition. Fish released prior to low flow conditions in the summer may have a greater influence on wild production than fish released after low flow when the relative amount of habitat increases. Moreover, non-migrant hatchery fish that are released at a larger size than resident wild fish may be competitively superior (Chapman 1962; Neuman 1956), and therefore have a greater impact on wild stocks.

Adjusting release times can reduce the amount of overlap between some species in freshwater and during early marine life. This strategy could reduce the impact of predaceous hatchery fish (e.g., chinook, coho, steelhead) on some wild stocks (e.g., sockeye, chinook), and could also reduce the likelihood of food limitations. Obviously, considerable information would be required on the timing, relative size, and movements of hatchery and wild fish in order to use this strategy.

Release Density

For migrant hatchery fish, releasing large numbers of fish can reduce predation mortality by swamping predators (Fresh et al. 1982; Peterman and Gatto 1978) and maximizing the advantages associated with schooling (Brock and Riffenburgh 1960; Major 1978). However, releases that are too large can result in food limitation. Large releases can also concentrate predators and increase predation on other fish populations (e.g., wild/natural fish) in the same area.

Release density may also influence false **migration** (Hillman and Mullan 1992). As a result, size-selective predation may increase due to reduced growth or force fish into habitats that increase their exposure to predators (Belford 1978; Healey 1979; Simenstad et al. 1982). Much information would be required to determine the window of optimum release density.

Release density may also be critical to survival of non-migrant hatchery fish if high release densities exacerbate density-dependent competition between hatchery fish and wild salmonids. Thus, spacing fish releases over a wide area and reducing the numbers released at any one location can effectively reduce these types of density-dependent effects. This would benefit both hatchery and wild fish. One method to accomplish this strategy is to use volitional release.

Release densities of hatchery fish can have both positive and **negative** effects on wild stocks.For example, a negative effect could result from density-dependent growth limitations and subsequent increases in predation of wild salmonids during marine life (Belford 1978). Conversely, hatchery fish may buffer wild fish from predation in some instances by "filling in" low smolt production of wild fish (of the same or different species), thereby reducing predation mortality of both (Peterman 1982).

Imprinting

Strategies to minimize straying of hatchery fish include:

- Careful selection of locations where adult broodstock will be captured.
- The hatchery location and type of water where fish will be incubated and reared.
- The location and type of water where the hatchery fish are released.
- The use of acclimation prior to release. Special attention should be given to ensure that hatchery fish are properly imprinted to the location where they are expected return as adults.

Hatchery Conditions

Hatchery conditions can have an effect on the ecological interactions that occur after fish are released into the natural environment. Rearing density, incubation techniques, disease incidence, and feeding strategy are all examples of hatchery conditions that can influence future ecological interactions (Beall 1972; Burrows 1969; Ginetz 1972;. Volovik and Gritsenko 1970). For example, fish reared at high densities appear to be more aggressive than fish reared at lower densities (Fenderson and Carpenter 1971). The high levels of aggression may intensify intra-specific competitive interactions (Fenderson et al. 1968). Consequently, one way to reduce competition, especially between hatchery and wild fish, may be to rear hatchery fish at lower densities.

Hatchery-caused stress can also influence species interactions. This stress may result from handling, excessive rearing densities, or disease. Many stresses enhance vulnerability to predators through a reduction in burst speed or foraging efficiency (Ginetz 1972; Popova 1978). Some hatchery practices (e.g., food delivery patterns) may promote maladaptive behaviors. Alternative food delivery patterns could be developed and tested (e.g., night feeding and subsurface feeding) that promote activity at times and in places where vulnerability to predators is reduced (Fresh et al. 1982, Volovik and Gritsenko 1970). Predator avoidance conditioning could also be utilized to reduce vulnerability of hatchery fish (Kanayama 1968; Patten 1977; Thompson 1966).

To make programmatic and **operational** changes to hatchery programs, some structural modifications to existing hatcheries may be required (i.e., construction of adult collection and juvenile acclimation facilities in suitable locations).

PERFORMANCE MEASURES

As discussed earlier, hatchery programs can **influence ecological** interactions that affect natural populations. Most of these interactions occur outside the hatchery environment. Therefore, it is imperative that they be addressed by fisheries managers in any decisions regarding use of hatchery fish. **Certain measures** can, however, be implemented in the hatchery to minimize the potential for adverse ecological effects. The performance measures outlined in this section address operational procedures that the hatchery directly controls, while also reflecting the importance of meeting management plan goals.

Performance standards are measured by answering the following questions:

1. Is the hatchery's program outlined in a subbasin management plan (e.g., Umatilla Basin Artificial Production Plan or Lower Snake River Compensation Plan)?

2. Is the hatchery operating under a current hatchery operational plan?

3. Is a hatchery monitoring and evaluation plan in place?

4. Does the hatchery program meet requirements established in the regional hatchery policies and subbasin planning documents in the following areas: species, stock, broodstock collection location, broodstock numbers, broodstock collection strategy, and spawning and egg-take protocols.

5. Does the hatchery's performance meet requirements outlined in the regional hatchery **policies and** in subbasin and hatchery plans for the following areas: percent smoltification, rearing density, disease condition, and **the** number, **size, date(s), and location** at release.

6. Are fish reared in the subbasin or acclimated in the subbasin?

7. Is the release strategy appropriate for the program?

EVALUATION

Several types of evaluation are envisioned in support of this policy: implementation, effectiveness, and adaptive management. Good evaluations will depend on clearly defined policy objectives, performance standards for each policy objective, appropriate evaluation and sampling design, collection and analysis of required data, and interpretation of results.

Chapter 7

Genetics Policy

Most of the man-caused fish mortality (NMFS 1993), and therefore the potential genetic change in Columbia Basin hatchery populations, takes place outside the control of hatchery operations. However, maintaining genetic variation and fitness in hatchery populations' requires that consideration be given to conserving genetic resources during all phases of hatchery operations.

Maintaining genetic diversity in hatchery populations is important to conserve'existing genetic traits necessary for long-term sustainability. Rearing and release guidelines that minimize adverse ecological interaction may also affect **genetic** diversity. These guidelines are addressed ***in the Chapter &Ecological Interactions Policy.***

Hatchery guidelines for fish collection, spawning, rearing, and release are dependent upon the individual hatchery program or purpose. These guidelines should be outlined in the individual **hatchery** operational plan. The policies and recommendations presented in this chapter are intended to help guide the development of the individual hatchery plans.

POLICY STATEMENT AND- GOALS

Policy Statement

It shall be the policy of the management entities of the anadromous salmonid resources in the Columbia Basin to operate artificial propagation programs that maintain adequate genetic variation and fitness in populations and protect the biological diversity of wild, natural, and cultured anadromous salmonid populations.

Goals

1. All fish produced and released meet identified management objectives for specific artificial production programs and follow genetic guidelines.

2. Monitor and evaluate implementation of genetic guidelines and genetic effects of artificially propagated fish on wild, natural, and cultured populations.

3. Foster open and frequent communications among managing entities to jointly resolve related issues.

PERFORMANCE STANDARDS

Genetic performance standards are designed to protect the fish population's ability to evolve, and thus persist in the face of environmental variability. Ultimately, fitness is demonstrated by the simple observation that a population has maintained its productivity over a long period of time. Stock fitness can be indexed, based on changes to (1) the recruit-tospawner ratio, (2) egg-to-adult survival, (3) survival between life history stages, (4) gene frequencies, or (5) life history patterns.

Long-term performance has always been a concern in evaluating salmon hatchery practices. This can be only be accomplished through new tools and evaluation efforts. Because of the variability in both hatchery programs and genetic theories, a singular approach is not appropriate for the genetic management of all Columbia Basin stocks. Therefore, a geneticist should be directly involved in developing and evaluating genetics programs at individual hatcheries.

Broodstock Collection

When starting a new hatchery population, choice of broodstock is the first decision to be made. For most of the existing Columbia. Basin hatcheries this decision was made years **ago.** Many of these hatchery stocks are valuable today **because** they contain genetic material that is no longer found in the wild, and because of their proven performance in the various fisheries.

Some broodstock-collections efforts in the region are using new donor stocks. These activities are related to the increasing trend of using hatcheries to rebuild ESA-listed stocks and for supplementation of natural stocks. Donor broodstock for these applications should be taken from the target population if sufficient numbers of broodstock are available.

When the target population is extinct or cannot be used for broodstock purposes, the stock that shows the greatest possible similarity in genetic lineage, life history patterns, and ecology of originating environment should be selected for broodstock use (CBFWA 1991; FAO 1982; Cuenco et al. 1993). In programs designed to maintain separation between hatchery and naturally spawning fish, the hatchery should utilize a stock that will have minimal gene-flow with naturally spawning stocks.

The following broodstock collection guidelines are designed to minimize selective pressures from hatchery practices:

1. The broodstock collected should represent the genetic variability of the stock by taking a unbiased, representative sample with respect to run timing, size, sex, age, and other traits identified as important for long-term fitness.

2. When collecting broodstock, the genetic protocol outlined in the individual hatchery operational plan that addresses the broodstock numbers needed to maintain genetic variability will be followed

3. For captive brood programs, collect eggs, juveniles, and/or adults so that they represent an unbiased, representative sample of the population. To minimize genetic risk, avoid using progeny from the captive brood program as donor stock for continued captive brood program. Whenever possible, avoid reincorporating full-sibling crosses into the broodstock.

Spawning Practices

To conserve the genetic diversity of the parent population, it is important to avoid artificial selection. This problem can be minimized by using the appropriate broodstock numbers, male-to-female spawning ratios, and fertilization **practices Artificial** selection can also be reduced by carefully selecting the egg-take **to be retained for** perpetuation of the run, and by considering alI returning fish as part of the population.

For all fish collected as hatchery broodstock, choose the mating scheme that will maintain effective population size. It is also important to maintain a large effective population size for each generation to minimize inbreeding and genetic drift.

Male-to-Female Ratios

1. **A** 1:1 male-to-female spawning ratio (single pair spawning, unpooled gametes) should be used for **each** day of spawning to maximize existing genetic variability.

2. If more than 500,000 eggs will be taken on a specific day, a male-to-female ratio no greater than 1:3 is acceptable.

3. In all cases, males should only be spawned once unless fertility is in question, or only when the sex **ratio** is unbalanced. Sperm should not be pooled.

4. Jacks should be used in the spawning operation to ensure that the genes associated with all age classes **are** incorporated in the population at an appropriate level.

5. Implement a “no selection” protocol (Tave 1986). For example, fish with poor secondary sexual characteristics should not be culled out. This is designed to conserve the gene pool.

Fertilization of ***Eggs***

The following criteria must be considered when determining appropriate fertilization procedures.

1. Within each group of adults that are "ripe" each spawning day, randomize matings with respect to size and other phenotypic traits.

2. Within each group of males and females that are "ripe" each spawning day, use at least the 1:1 mating scheme, but carefully evaluate if the status of the population warrant use of another scheme.

3. If fertility is consistently high across males and egg supply is not severely limited, apply the 1:1 scheme by fertilizing with sperm of one male, never using a male more than once.

4. To ensure full fertilization when the egg supply is severely limited or male fertility is highly variable (e.g., due to poor sperm motility), successively use two males for each egg lot (1 and 2; 2 and 3; 3 and 4, etc.). This procedure utilizes the first of the pair (with mixing), followed by interval of 30 seconds, and then the immediate use of the second male. Only one pair (i.e., pair l-2) will be used to fertilize the eggs, or subset of eggs of one female. Use each pair only once (e.g., sperm pair l-2 is used to fertilize eggs of only one female);

5. On spawning days where one sex is more numerous, use a pairing scheme on a portion of the matings to avoid discarding excess spawners. This can be used on all populations, except those that are critically small.

6. For critically small populations, consider app1ying a splitting and/or pairing scheme to all matings that day to maximize allelic and genotypic diversity.

7. In cases where females are extremely limited, fertilize each subset of a female's eggs with sperm of a different male, until all available females and the desired number of males are mated.

8. Only in cases where males are the least numerous sex, cross each subset of a male's sperm with eggs of a different female, until all available males and the desired number of females are used.

9. Mate all selected broodstock, using gamete storage techniques if necessary.

10. Make sure that all mature parents contribute equally to the spawn-taking. Combine gametes from single pairs of parents. If presented with an excess number of one sex, gametes from individual parents may be subdivided and each part fertilized with gametes from different parents.

Selection of *Egg Take (to' be retained by the hatchery for perpetuation* of *the run)*

The goal is to use eggs that are representative sample of the spawning population. The best means of reducing the number of eggs to be retained is by taking a portion of eggs from each male/female cross.

Evaluation

The goals of an evaluation program are to:

1. Avoid inbreeding and genetic drift.

2. Monitor physical characteristics, survival by life stage, and fitness of all stocks. Consult with a geneticist to develop corrective action if significant changes occur.

3. Maintain heterozygosity of managed stocks while avoiding long-term changes.

4. Maintain between-population diversity.

5. Design a program, with involvement of a geneticist, to monitor and evaluate the program's progress. The production program must preserve parental stocks, monitor physical characteristics, and monitor survival by life stage of all stocks.

PERFORMANCE MEASURES

Compliance with performance standards relating to broodstock selection, spawning and evaluation are measured by answering following questions:

1. For new programs, has a broodstock collection plan been developed?
2. For new programs, was the donor selection outline followed in selecting the hatchery broodstock?
3. For existing programs, were the broodstock collection procedures followed?
4. Were the appropriate number of spawners, male/female ratios, and fertilization protocols used?
5. Is there a genetic monitoring and evaluation program in place?

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IMPLEMENTATION

Members will prepare a yearly report that describes the following items:

1. Collection of wild broodstock for use in hatchery programs
2. Characteristics of the wild population, when possible, as well as the fish collected for use in the hatchery
3. Daily and seasonal mating schemes for each fish stock reared at a hatchery as outlined
4. Male/female spawning ratio used, the egg fertilization procedures, and the selection of eggs if not all used for rearing
5. Description of any rearing or release methods that purposely select for size, morphology, behavior, physiological status, health or other ecological attributes not considered in the operating plan. This will include a description of any culling that was purposely performed and the results expected.

6. Any significant changes in symmetry, survival by life stage, or fitness

New programs requiring collection of hatchery broodstock from wild populations will require a broodstock collection plan that considers the performance standards outlined in this chapter. This will be created consulting a geneticist, the local habitat biologist, and the appropriate fishery managers. This broodstock collection plan will become a part of the yearly operating plan.

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Glossary

The following definitions apply to.IHOT policies and other information presented in this publication.

acclimation	The process of rearing and imprinting juvenile fish in the water of **a** particular stream before fish are" released into that stream.
adaptive management	A scientific policy that seeks to improve management of biological resources 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 different elements of the system are better understood.
AFS Fish Health Blue Book	The most recent edition of "Procedures for the Detection and Identification of Certain Fish Pathogens" published by the Fish Health Section of the American Fisheries Society.
alevin (sac fry)	A life stage of salmonid fish between hatching and feeding stages when the yolk sac has not been absorbed and fish are not dependent on external food sources for nourishment.
amplification	The process of increasing the magnitude of pathogens or disease within the basin, tributary, or facility.
anadromous	Fish that hatch in fresh water and migrate to salt water to mature before returning to spawn in fresh water.

aquatic ecosystem Any standing or moving body of water such as a stream or lake, and all of the interacting living and non-living components functioning as **a** natural system.

Artificial Fish Productlon Committee (AFPC) A coordinating **entity** for hatchery production activities within the Columbia River Basin.

Assumed Pathogen Prevalence Level (APPL) The percentage of any fish lot (e.g., 2%, 5%, or 10%) that is assumed to have a pathogen **at a** detectable level using. tests outlined in the AFS "Fish Health Blue Book." This level is used to determine the sample size needed to provide **a** 95% confidence level of finding the specified pathogen.

Basin As used here, all waters of the Columbia River and its watersheds.

biological dlverslty The array of genetic, physical, life history and behavior characteristics contained within the salmon and steelhead resources of the Columbia River Basin.

biological requlrements Environmental components such as water quality, **water** quantity, food availability, and habitat that are necessary for fish growth and reproduction.

brood year The year in which a majority of the adults in a population of fish are spawned.

broodstock All adult salmonids collected or captured from the waters of the Columbia River Basin for the purpose of collecting eggs and/or milt. Adult fiih collected or captured temporarily, but released **unspent,** are not considered broodstock.

captive broodstock Salmonids that have been reared from eggs or juveniles to maturity in captivity for the collection of gametes.

co-managers Federally recognized Indian tribes within the Columbia Basin, and the states of Idaho, Oregon, and Washington, the U.S. Fish and Wildlife Service, and the National **Marine Fisheries Service.**

competltlon The direct or indirect interaction among organisms of the same or different species that utilizes a common resource.

confirmed viral The identification of a replicating viral agent by serum

Identification	neutralization assay, or other confirmatory test agreed to by the co-managers.
cultured fish	See "hatchery-produced fish."
Current Brood Document	The production document reflecting coordinated inseason changes to the Future Brood Document. The format will be virtually identical to the Future Brood Document.
disease	An alteration of a living body that impairs its functioning. Can be biotic or abiotic.
disease inspection	The collection and examination of a statistically valid sample of fish tissues and/or fluids for detection of pathogens. Examinations are to conducted by or under the supervision of an accredited inspector.
dissemination	The spread of pathogens or disease beyond the present or normal geographical or host range within the basin or tributary.
ecological interactions	The overlapping of resource needs and uses (e.g., food, cover, spawning habitat) that determines the relationship between individual fish populations and species in the aquatic environment.
egg bank	The use of artificial propagation to maintain a genetic stock of fish until such time as the natural habitat is restored.
egg disinfection	The immersion of eggs in a concentration of a therapeutic 'drug for a specified period of time to reduce or eliminate pathogens that may exist or the external surface of the eggs-
epizootic	The occurrence of an infectious disease that results in an average daily mortality of at least 0.1% per day within a specific rearing unit for five consecutive days.
exotic fishes	Non-native fishes.
eyed eggs	The embryo stage at which pigmentation of the eyes becomes visible through the egg shell.

fish displacement — The movement of ‘an individual or group of fish from its preferred habitat resulting from the introduction of cultured fish or an increase in naturally produced fish.

fish hatchery — A facility at which one or more of the following occurs: adult broodstock holding, egg collection and incubation, egg hatching or fish rearing.

fish liberation — The release of captive fish into public waters that results in them being free-ranging.

fltness — The relative ability of an individual to contribute to the next generation.

Future Brood Document (FBD) — The annual production document reflecting detailed hatchery goals or expectations coordinated and prepared prior to the adult arrival **season.** These goals include location, stock of fish, eggtake, transfer, and release. A goal will include elements of number, size, and time of activity (i.e., transfer or release).

genetic dlverslty — The range of genetic differences among individuals or groups of organisms.

genetic Interaction — Direct interbreeding between a stock of hatchery fish and wild, natural or another hatchery stock of fish.

genetlc rlsk — The extent to which **a** management practice may reduce population productivity or cause **an** undesirable change in genetic characteristics of a population.

genetlc varlatlon — The measurable or observable genetic differences among individuals or populations.

genotype — The kinds of and the combination of genes possessed by an individual.

goal — The desired direction of a program leading to the creation of policies and operational plans for policy implementation.

hatchery-produced fish — A fish incubated or reared under artificial conditions for at least a portion of its life cycle.

hatchery flsh production — The number or pounds of fish raised and produced in **a** hatchery.

hatchery program
A program in which **a** specified hatchery population is released in a specified geographical location, following a prescribed resource management plan.

harvest augmentation
The stocking of **anadromous** fish where the primary **purpose** is to return adults for sport, commercial, or tribal **harvest.**

Integrated Hatcheries Operatlons Team (IHOT)
The coordinating **entity** for hatchery practices within the Columbia River Basin.

Inspectlon
The collection and examination of a statistically valid sample of fish tissues and/or fluids for the listed pathogens by or under the supervision of an accredited inspector.,Methods used will be those described in the "Fish Health Blue Book" or others mutually agreed to by the co-managers' fish health staff.

Introduction
Releasing a hatchery reared species into habitat where it was not native.

Iodophor water-hardenlng eggs
The exposure of recently fertilized eggs (not more than five minutes exposure to water) to a buffered iodophor solution of at least 75 ppm **active** iodine for one hour. The minimum ratio of iodophor solution to eggs (volume to volume) will be two parts iodophor solution to one part eggs. Discard the used solution once the ratio has been met.

Isolation
The process of keeping a group of eggs or fish physically and environmentally separated from other groups at the same facility for the purpose of preventing cross contamination with possible pathogens.

jack
A precociously mature anadromous salmonid that has matured before the majority of fish spawned in the same year.

lot (of fish)
A group of hatchery fish of the same species and brood year, that originated from the same discrete spawning population, and that have **always** shared a common water supply

management plan	A plan that provides the basic framework (goals, policies, and objectives) for managing a resource, geographic area, watershed or species.
mltlgatlon	The use of artificial propagation to reduce or replace losses to a natural fish population caused loss of critical habitat or other factors.
natural spawnlng fish	Fish produced by spawning and rearing in natural habitat, regardless of the parentage of the spawners.
natural spawnlng augmentatlon	The release of hatchery-produced eggs and/or fish that are qualitatively similar to the size, physiological status, and life stage of existing natural spawning species, while meeting known ecological, genetic and fish health guidelines.
operational plan	An action plan that generally addresses how the objectives in a management plan for harvest or production for a specific area shall be **attained.**
parr	A young anadromous salmonid during the freshwater-rearing phase of its life cycle, generally an actively feeding stag-lder than a fry and yet not ready to migrate to the ocean.
pathogen	A disease-causing agent.
performance measures	The means for determining or measuring the achievement of standards.
performance standards	Accepted criteria for evaluating biological, physical or operational hatchery parameters.
phenotype	Observable **characteristics** of an organism, determined by its genes and their interaction with the environment.
PNFHPC	Pacific Northwest Fish Health Protection Committee
policy	An accepted course or line of **action to** guide and determine present and future decisions.
population	A group of fish belonging to the same species that occupy a well-defined locality and do not interbreed to any substantial degree with any other group of fish and have separate dynamic histories.

predatlon — The consumption of wild or hatchery origin fish by other fish (including other salmonids), birds, or mammals.

presmolt — A juvenile anadromous salmonid **that** has fed and reared, but is not yet **a** smolt.

presumptlve viral Identlflcatlon — The detection of **a replicating agent** in cell cultures inoculated with fish tissues or fluids. Presumptive identification is made when cytopathic effect (CPE) is observed in cell culture.

quarantlne — Isolating a group of eggs or fish from others. Treating 'effluent and/or influent waters as necessary to prohibit the transfer of pathogens.

reportable pathogens — The following pathogens are reportable:

viral - Infectious hematopoietic necrosis virus (IHNV)
- Infectious pancreatic necrosis virus (IPNV)
- Oncorhynchus masou virus (OMV)
- Viral hemorrhagic septicemia virus (VHSV)

bacterial - Renibacterium salmoninarum (Rs) (BKD)

parasite - *Myxobolus cerebralis*

satellite faclIltles — Extension of hatchery facilities located away from the fish hatchery where juveniles may be acclimated, conditioned, reared, and released or where adults are captured, held, and spawned.

smolt — A juvenile anadromous salmonid fish that has reached a physical size and physiological state that is capable of migrating into salt water.

species — One or more stocks whose members interbreed under natural conditions and produce fertile offspring, and who are reproductively isolated from other such groups.

specific pathogen-free water Water that is free of specified reportable pathogen(s). This includes untreated groundwater; water that has been treated to approved standards with chlorine, ozone, ultraviolet light, or equivalent; or is demonstrated to be fish-free. Untreated surface water that is free of anadromous stocks is determined to be specific pathogen-free if for the past three consecutive years all captive broodstocks and susceptible juvenile stocks on station have been inspected without detection of the specified reportable pathogen. Inspections must have been conducted using at least the number of fish required to meet the 5% APPL and the time period between adult or juvenile inspections must be **at** least 11 months. In addition, any **diagnostic cases** involving any stock on site during the same three years must have been free of the specified reportable pathogen(s).

stock An aggregation for management purposes of fish populations **that** typically share common characteristics such as life histories, migration patterns, or habitats.

stray A fish returning to a non-natal stream, place of release, or place of spawning.

subbasln The individual watersheds of Columbia River tributaries.

supplementatlon The use of artificial propagation in the attempt to maintain or increase natural production, while maintaining, the long-term fitness of the target population and keeping the ecological and genetic impacts on non-target populations within specified biological limits.

transfer Any movement of fish into or within the Columbia River Basin to include any movements among hatcheries, rearing facilities, and watersheds.

wlld fish A stock of fish maintaining **a** population through natural reproduction with no directed hatchery influences.

water supply The spring, well, stream, river, estuary, or other body of water used in the incubation/rearing of eggs or fish.

watershed Geographically distinct river basins that have separate entrances to the Columbia or Snake rivers.

Appendix A

Suggested Experimental Rearing Techniques for Natural Spawning Augmentation

1. Provide rearing containers with natural materials such as sand and gravel.

2. Provide in-water **structures in rearing containers.**

3. **Provide incubation under low-light or dark conditions.**

4. **Manipulate egg development during incubation through use of** controlled water temperatures to mimic natural incubation.

5. Provide for volitional movement of swim-up fry to feeding areas in rearing containers.

6. Provide predator avoidance training methodology to develop behavioral and **physiological characteristics.**

7. **Provide** for exercising of fish.

8. Provide rearing containers with colors **matching** natural background **and/or overhead cover to allow fish to adapt to natural conditions.**

9. Minimize direct human contact with fish during feeding through use of **equipment such as underwater food dispensers while simulating natural feeding patterns in relation to timing and amount of food offered.**

10. Provide for incubation of eggs and alevins under density, substrate, and water quality conditions that simulates the natural intergravel environment.

11. Provide for maintaining natural noise levels across sound frequency heard by fish.

12. Provide for use of natural foods.

13. Test methods to improve smolt survival by allowing them to learn skills from wild fish.

Appendix B

Water Quality Criteria for Salmonid Aquaculture

Appendix Table B-l. Water quality criteria for salmonid aquaculture (ADFG 1986). Synergistic and antagonistic chemical reactions must be considered when evaluating a water source against these criteria.

Water Qualities	Standards
Aluminum	<0.01 mg/liter
Ammonia (un-ionized)	<0.0125 mg/liter
Arsenic	<0.05 mg/liter
Barium	<5.0 mg/liter
Cadmium	~0.0005 mg/liter (100 mg/liter alkalinity) <0.005 mg/liter (≥ 100 mg/liter alkalinity)
Carbon Dioxide	<1.0 mg/liter
Chloride	<4.0 mg/liter
Chlorine	<0.003 mg/liter
Chromium	<0.03 mg/liter
Copper	<0.006 mg/liter (100 mg/liter alkalinity) <0.03 mg/liter (≥ 100 mg/liter alkalinity)
Dissolved Oxygen	>7.0 mg/liter
Fluorine	<0.5 mg/liter
Hydrogen Sulfide	<0.003 mg/liter
Iron	<0.1 mg/liter
Lead	<0.02 mg/liter

Appendix Table B-l (Continued)

Water Qualities	Standards
Magnesium	<15 mg/liter
Manganese	<0.01 mg/liter
Mercury	<0.0002 mg/liter
Nickel	<0.01 mg/liter
Nitrate (NO^3)	<1.0 mg/liter
Nitrite (NO^2)	<0.1 mg/liter
Nitrogen (N^2)	<110% total gas pressure; <100% nitrogen gas
Petroleum (oil)	<0.001 mg/liter
pH	6.5 - 8.0
Potassium	<5.0 mg/liter
Salinity	<5.0 parts per thousand
Selenium	<0.01 mg/liter
Silver	<0.003 mg/liter (fresh water); <0.0003 mg/liter (salt water)
Zinc	<0.005 mg/liter
Sodium	<75.0 mg/liter
Sulfate ($SO^{4\ -2}$)	<50.0 mg/liter
Temperature	0^o - 15^oC
Total Dissolved Solids	<400.0 mg/liter
Total Settleable Solids	<80.0 mg/liter (25 JTU)

Appendix C

Fish Transportation Guidelines

DISINFECTING THE UNIT

As a safeguard against contamination by diseases, all fish transport equipment must be disinfected before and immediately after use. Any other equipment that might be infected (e.g., nets, buckets, pipes, hoses, boots, raincoats) must also be disinfected.

Disinfection is reauired when:

1. Using transportation equipment at facilities that have different water supplies.

2. Using transportation equipment for moving different species or age classes from the same facility.

3. Moving equipment between hatcheries/facilities.

Disinfection is not reauired when hauling different fish lots of the same species from the same facility, if all lots have the same disease status. Guidelines for disinfecting vehicles and equipment are provided in the sections to follow.

Disinfectant

Transport water is to be loaded at pathogen-clean stations far from well water.

Fish Tank Interior

Chlorine

Fish tank interiors should be disinfected using a solution of 200 ppm active chlorine in the form of liquid bleach (sodium hypochlorite, 5.25% active ingredient or calcium hypochlorite HTH, registered, 65% active ingredient chlorine for 30 minutes minimum). After sanitation, the solution should be dumped at a safe site where it will not directly drain into natural waters. Neutralization of chlorine is recommended. This can be accomplished using 2.2 pounds of sodium thiosulfate per pound of HTH, or 1.5 gm sodium thiosulfate/liter of 200 ppm chlorine.

because chlorine can be corrosive to metal, equipment should be cleaned using clean, uncontaminated water following use. Rain gear should be worn to prevent or reduce chlorine contact with clothing. Organic substances will quickly inactivate chlorine and limit its effectiveness. Therefore, dirty equipment should be cleaned with water before the equipment is sanitized with chlorine. Waste water from the cleaning should be properly discarded.

Formaldehvde eas generation

This method will effectively sanitize vehicle interiors and exteriors. It also offers several advantages as cleanup is reduced, toxicity is negligible, and the procedure is simple. Relative humidity is important as humidity of 60 percent is required for a 2-hour dose.

1. Interior surfaces: Add 0.3 ml of full strength formalin into (33 percent) 0.15g $KMnO_4$ for each cubic meter to be treated. After mixing these two ingredients together, stay away for 24 hours. The combination produces formaldehyde gas. When the formaldehyde gas dissipates, no after-odor is detectable. At relative humidity of 60 percent, only 2 hours of contact time is needed.

2. Exterior surfaces: Wash mud from vehicles at a site that is away from natural water bodies. Cover vehicle or drive it into an enclosure. Add appropriate amounts of chemicals, leave immediately, and stay away for 24 hours.

Fish *Transport* Vehicle *Exterior*

The exterior of motor vehicles, including chassis and undercarriage, can be disinfected using high pressure steam (115-130°C) high temperature acid, or with 200 ppm chlorine for 30 minutes. Chlorine should be thoroughly rinsed with clean, uncontaminated water to minimize corrosion. It is not necessary to disinfect the exterior of aircraft or boats used for transporting fish or eggs.

Fish Transport Vehicle *(cab)*

Interior surfaces (floor) of motor vehicles, aircraft, or boats contaminated by contact with fish, eggs, mud, or cultural waters should be scrubbed with 600 ppm quaternary ammonia compounds (i.e., Hyamine, Roccal, or Environquat). Roccal and Hyamine is also acceptable (1.5 ml of 50 percent stock solution / liter water).

Other Equipment

Utensils, fish pumps, nets, egg sorters, waders, boots, rain gear, hoses, and other equipment can be disinfected using one of these solutions:

- 200 ppm chlorine for 30 minutes
- 600 ppm quaternary ammonia compound for 30 minutes
- 200 ppm iodophor solution for 10 minutes

If necessary, the disinfectants should be scrubbed onto the surface and disinfected equipment should be thoroughly rinsed with clean, uncontaminated water and dried before use.

Personnel

All individuals involved in transport operations should wear outer protective garments (rain gear, boots, waders, etc.) when handling fish, eggs, or cultural water. Hands should always be thoroughly washed before handling cultural water at another station. When work is completed at the station, protective garments and hands should be properly sanitized. Natural cotton and wool fabrics, that contact cultural water at another station, can be sanitized by soaking for 30 minutes in 600 ppm quaternary ammonia compound. Regular clothes washing would also be appropriate.

Neutralizing Chlorine

Chlorine can be neutralized by adding 2 ppm of sodium thiosulfate for every 1 ppm of chlorine for 15 minutes. Rinse with clean water. Use 4 grams of sodium thiosulfate per 5 gallons of 100 ppm chlorine water.

Disposing of Treatment Solutions

Locations suitable for disposal of treatment solutions are listed below.

1. Settling ponds (sodium thiosulfate if fish kill is possible)
2. Empty hatchery pond (no outflow allowed)
3. Hatchery pond full of water but no fish
4. Ground where water will not reach irrigation ditches, streams, lakes, ponds, or water bodies of any kind.
5. If the above conditions cannot be met, neutralize with sodium thiosulfate.

UNIT INSPECTION BEFORE THE TRIP

The fish transport truck/chassis and tank/unit should be inspected and serviced at least two weeks prior to release season. Maintenance on the truck/chassis and tank/unit along with associated equipment should be completed during winter months. Equipment should be operated under simulated fish transport conditions just prior to release season. Miscellaneous equipment and supplies (e.g., oxygen bottles, oxygen regulators, pumps, generators, nets, screens, hoses, fittings, spare tire, jack, lug wrench, fire extinguisher, first aid kit) must be checked and verified to be in good working order.

Truck drivers must carry proper license endorsements as.required by state law.

A daily service inspection should be completed before starting up and leaving for the day. This inspection should cover the following actions:

- Check engine oil.
- Check radiator water level.
- Check fan belt(s) tension.
- Check all lights.
- Check fuel system for leakage and make sure tanks are full.
- Check lug nut tightness.
- Check brakes.
- Check to make sure all hatches are shut, caps and outlets, slide gates within tank are closed, and all liberation hoses are on the truck.

UNIT INSPECTION BEFORE LOADING

1. Prior to loading the tank with water, a complete walk-around inspection should be completed to make sure that all drains are closed and the gate is down and locked.

2. Prior to loading water, turn on the oxygen to ensure that the air stones/diffusers do not fill with water. If water backs up into the air lines, it could create a system airlock until the water is pushed back through the air stones/diffusers. This reduces the efficiency of the system.

3. After the tank is loaded with water, start the back-up systems (i.e., pumps, generators, etc.) to verify that they are operating properly. Increase the oxygen to 5-6 liters per minute to supercharge the water to about 15 ppm prior to loading fish.

4. When the truck is in place for loading fish, check the oxygen flow/pump pressure for the correct setting to ensure it did not change while moving the truck. Check the spray from either the aerators or the pump spray bars, and verify that the air stones/diffusers are working properly and are not leaking.

5. Verify that the displacement gauge does not have an airlock and that it is set at the proper angle. Note: trucks should be setting as level as possible.

HATCHERY PRE-LOADING RESPONSIBILITIES

Each hatchery should have a place available to dispose of treatment solution. The hatchery is responsible for scheduling and ensuring the completion of a disease inspection, and that the fish have been cleared for transport.

The hatchery should provide means of loading clean water, either from a standpipe, or a pump set up in the head box or head end of a pond. Water should not be pumped from the downstream end of the rearing ponds.

The hatchery should provide a level loading area for liberation trucks to insure that fish displacement is accurate.

To minimize the buildup of metabolic waste and oxygen consumption in the tank, fish under 8 inches must be starved for a minimum of 48 hours before hauling. Fish larger than 8 inches should be starved for 72 hours.

LOADING FISH

Tank Water Level

The transport tank should be filled with water approximately 15 minutes before loading with fish. The oxygen should be turned on to supercharge the water to 15 ppm before loading the fish. Any required ice should be added prior to loading fish.

Pump(s) or Aerator(s)

Each liberation unit is equipped with either an aeration system or a recirculating system to dissipate the carbon dioxide gases and to help increase the oxygen content in the water. Aeration systems equipped with 12-volt Fresh-Flo model TT aerators (or equivalent) should be wired to a separate circuit. This is needed so that if one aerator shorts out, the other aerators will continue to function properly. Circuits should be checked prior to loading fish to make sure they are all working. Aerators should be checked to make sure they are rotating the correct direction and pumping water. Each aerator should have an indicator light inside the truck cab to warn of malfunctions while truck is enroute.

Liberation units with a recirculating system should have a venturi system (which pulls in atmospheric oxygen) or an oxygen system. If the liberation unit has a venturi system, it should be checked prior to loading fish to make sure each venturi is pulling air into the system. This can be accomplished by holding your hand over the venturi, with the unit running, and feeling a suction on your hand. If an oxygen system is used, check the air stones/diffusers to make sure they are working properly.

Oxygen Injection System Settings

Each liberation unit equipped with an oxygen injection system has either a pre-set medical oxygen regulator (calibrated in liters per minute), or a welding-type oxygen regulator with a flow meter(s) between the regulator and the air stones/diffusers. On liberation units with the medical oxygen regulator, the pressure is pre-set. The only adjustment required is to set the desired liters per minute for the air stones/diffusers.

On units with the welding type oxygen regulator, the pressure needs to be set at.50 psi (do **not** set the regulator over 50 psi). Each flometer needs to be set separately in liters per minute.

Each liberation unit requires different settings. Correct settings for the air stones/diffusers should be identified on the equipment.

The tank system should have 15 ppm of oxygen for 15 minutes prior to loading fish. This should be maintained for first 45 minutes to 1 hour, then the setting on flow meters should be reduced to maintain oxygen at 8 ppm.

Displacement Gauge

All liberation units must be equipped with displacement gauges. These gauges are to be initially calibrated initially when a new tank is put into service, or when the internal configuration is changed due to maintenance, adding baffles, or other tank modifications. Displacement gauges should be checked and data recorded periodically throughout the season by weighing fish.

Truck Loading/Hauling Density Tables

Truck loading/hauling density tables are provided at the end of this appendix. These tables are to,be used as general guidelines; they can be revised to meet specific requirements. Tables are based upon four hours of loading/hauling time and water temperatures of 48-52°F. For each additional hour of hauling time, reduce the load by 4 percent. For each degree above **52°F,** reduce the load by 5.6 percent.

HAULING FISH

Fish should be checked 45 minutes to 1 hour after loading. If the fish are active and all the systems are functioning properly, reduce the oxygen to maintain approximately 8 ppm. Every effort should be made to minimize transport stress. Fish **and** all systems should be continually checked each hour.

The most suitable temperature range for **transporting** fish is **42-48°F.** Fish should not be hauled in water above 53°F (Leitritz and Lewis 1980). Some liberation units are refrigerated, which allow the driver to set and maintain the desired temperature. If there is no refrigeration unit, a cool source of water at the hatchery is needed. During warm weather, ice may be needed to help chill the water to the desired hauling temperature.

Hatcheries need to be aware of temperature of water source for liberation units and have an adequate supply of chlorine-free ice on hand to ensure that correct hauling temperatures can be reached. Vehicles should carry a list of local vendors who carry ice.

RELEASING FISH

Correct Release Site

It is very important that fish are released into the correct water body and sites as indicated on the Fish Liberation Schedule. Each liberation truck should have an updated liberation site / map and the driver should become familiar with all the water bodies and site descriptions.

Tank Temp vs. Water Body Temp (Tempering)

The difference in temperatures between the liberation tank and target water body should not exceed **10°F.** If temperature range is greater then **10°F,** water from planting site should be pumped into the top of the tank while drafting water out of the bottom. After water in the tank has reached the correct temperature, wait for at least 30 minutes to allow fish to acclimate themselves to the temperature change before releasing them.

Hose Angle

The liberation hose should be angled so that released fish gently hit the water. One method of ensuring the hose will stay at the proper angle is to support the hose on a tripod or similar support.

TRUCK LOADING/HAULING DENSITY TABLE

by species and by operating capacity of truck

Summer Steelhead, Sockeye & Fall Chinook

Note: Table is based upon 4 hours hauling time and water temperature of 48 F to 52 F.

F/lb Oper gals	3000	550	200	loo	75.0	60.0	40.0	20.0	16.0	12.0	7.5	5.0	3.5	2.5
3000	900	1130	1740	2160	2190	2220	2280	2460	2520	2550	2580	2580	2640	2670
2900	870	1090	1680	2090	2120	2150	2200	2380	2470	2470	2490	2490	2550	2580
2800	840	1050	1620	2020	2040	2070	2130	2300	2380	2380	2410	2410	2460	2490
2750	830	1030	1600	1980	2010	2040	2090	2260	2340	2340	2370	2370	2420	2450
2700	810	1010	1570	1940	1970	2000	2050	2210	2300	23m	2320	2320	2380	2400
2600	780	980	1510	1870	1900	1920	1980	2130	2210	2210	2240	2240	2290	2310
2500	750	940	1450	1800	1830	1850	1900	2050	2130	2130	2150	2150	2200	2230
2400	720	900	1390	1730	1750	1780	1820	1970	2040	2040	2060	2060	2110	2140
2300	690	860	1330	1660	1680	1700	1750	1890	1960	1960	1980	1980	2020	2050
2200	660	830	1280	1580	1610	1630	1670	1800	1870	1870	1890	1890	1940	1960
2100	630	790	1220	1510	1530	1550	1600	1720	1790	1790	1810	1810	1850	1870
2000	600	750	1160	1440	1460	1480	1520	1640	1700	1700	1720	1720	1760	1780
1900	570	710	1100	1370	1390	1410	1500	1560	1620	1620	1630	1630	1670	1690
1850	560	690	1070	1330	1350	1370	1430	1520	1570	1570	1590	1590	1630	1650
1800	540	680	1040	1300	1310	1330	1370	1480	1530	1530	1550	1550	1580	1600
1500	450	560	870	1080	1100	1110	1140	1230	1280	1280	1290	1290	1320	1340
loo0	300	380	580	720	730	740	760	820	850	850	860	860	880	890
900	no	340	520	650	660	670	680	740	770	770	770	770	790	800
800	240	300	460	580	580	590	610	660	680	680	690	690	700	710
500	150	190	290	370	370	370	380	410	430	430	430	430	440	450
300	90	110	170	220	220	220	230	250	260	260	260	260	260	270
250	80	90	150	180	180	190	190	210	210	210	220	220	220	220
225	70	80	130	160	160	170	170	190	190	190	190	190	200	200
200	60	80	120	150	150	150	150	160	170	170	170	170	180	180
175	50	70	100	130	130	130	130	140	150	150	150	150	150	160

For each hour of hauling time above 4 hours, reduce load by 4.0%
For each degree F above 52, reduce load by 5.6%
For each degree F below 48, increase load by 5.6%

TRUCK LOADING/HAULING DENSITY TABLE

by species and by operating capacity of truck

Winter Steelhead

Note: **Table is based upon 4 hours hauling time and water temperature of 48 F to 52 F.**

F/lb	3000	550	200	100	75.0	60.0	40.0	20.0	16.0	12.0	7.5	5.0	3.5	2.5
Oper gals														
3000	900	1050	1500	1880	2180	2330	2630	3oa	3080	3110	3120	3140	3140	3140
2900	870	1020	1450	1810	2100	2250	2540	2960	2970	3000	3020	3030	3030	3030
2800	840	980	1400	1750	2030	2170	2450	2860	2870	2900	2910	2930	2930	2930
2750	830	960	1380	1720	1990	2130	2410	2810	2820	2850	2860	2870	2870	2870
2700	810	950	1350	1690	1960	2090	2360	2750	2770	2800	2810	2820	2820	2820
2600	780	910	1300	1630	1890	2020	2280	2650	2670	2690	2700	2720	2720	2720
2500	750	880	1250	1560	1810	1940	2190	2550	2560	2590	2600	2610	2610	2610
2400	720	840	1200	1500	1740	1860	2100	2450	2460	2490	2500	2510	2510	2510
2300	690	810	1150	1440	1670	1780	2010	2350	2360	2380	2390	2400	2400	2400
2200	660	770	1100	1380	1600	1710	1930	2240	2260	2280	2290	2300	2300	2300
2100	630	740	1050	1310	1520	1630	1840	2140	2150	2170	2180	2200	2200	2200
2000	600	700	1000	1250	1450	1550	1750	2040	2050	2070	2080	2090	2090	2090
1900	570	670	950	1190	1380	1470	1660	1940	1950	1970	1980	1990	1990	1990
1850	560	650	930	1160	1340	1430	1620	1890	1900	1920	1920	1930	1930	1930
1800	540	630	900	1130	1310	1400	1580	1840	1850	1860	1870	1880	1880	1880
1500	450	530	750	940	1090	1160	1310	1530	1540	1550	1560	1570	1570	1570
1000	300	350	500	630	730	780	880	1020	1030	1040	1040	1050	1050	1050
900	270	32.0	450	560	650	700	790	920	920	930	940	940	940	940
800	240	280	400	500	580	620	700	820	820	830	830	840	840	840
500	150	180	250	310	360	390	440	510	510	520	520	520	520	520
300	90	110	150	190	220	230	260	310	310	310	310	310	310	310
250	80	90	130	160	180	190	220	260	260	260	260	260	260	260
225	70	80	110	140	160	170	200	230	230	230	230	240	240	240
200	60	70	100	130	150	160	180	200	210	210	210	210	210	210
175	50	60	90	110	130	140	150	180	180	180	180	180	180	180

For each hour of hauling time above 4 hours, reduce load by 4.0%

For each degree F above 52, **reduce** load by 5.6%

For each degree F below 48, **increase load** by 5.6%

TRUCK LOADING/HAULING DENSITY TABLE

by species and by operating capacity of truck

spring & summer Chinook

Note Table is based upon 4 hours hauling time and water temperature of 48 F to 52 F.

F/lb Oper gals	3000	550	200	100	75.0	60.0	40.0	20.0	16.0	12.0	7.5	5.0	3.5	2.5
3000	900	1350	2000	2250	2430	2630	3000	3680	3740	3770	3830	3840	3890	3930
2900	870	1310	1930	2180	2350	2540	2900	3550	3610	3640	3700	3710	3760	3800
2800	840	1260	1870	2100	2270	2450	2800	3430	3490	3510	3570	3580	3630	3670
2750	830	1240	1830	2060	2230	2410	2750	3370	3420	3450	3510	3520	3560	3600
2700	810	1220	1800	2030	2190	2360	2700	3310	3360	3390	3440	3460	3500	3540
2600	780	1170	1730	1950	2110	2280	2600	3190	3240	3260	3320	3330	3370	3410
2500	750	1130	1670	1880	2030	2190	2500	3063	3110	3140	3190	3200	3240	3280
2400	720	1080	1600	1800	1940	2100	2400	2940	2990	3010	3060	3070	3110	3140
2300	690	1040	1530	1730	1860	2010	2300	2820	2860	2890	2930	2940	2980	3010
2200	660	990	1470	1650	1780	1930	2200	2700	2740	2760	2810	2820	2850	2880
2100	630	950	1400	1580	1700	1840	2100	2570	2620	2640	2680	2690	2720	2750
2000	600	900	1330	1500	1620	1750	2000	2450	2490	2510	2550	2560	2590	2620
1900	570	860	1270	1430	1540	1660	1900	2330	2370	2390	2420	2430	2460	2490
1850	560	830	1230	1390	1500	1620	1850	2270	2300	2320	2360	2370	2400	2420
1800	540	810	1200	1350	1460	1580	1800	2210	2240	2260	2300	2300	2330	2360
1500	450	680	1000	1130	1220	1310	1500	1840	1870	1880	1910	1920	1940	1970
1000	300	450	670	750	810	880	1000	1230	1250	1260	1280	1280	1300	1310
900	270	410	600	680	730	790	900	1100	1120	1130	1150	1150	1170	1180
800	240	360	530	600	650	700	800	980	1000	1000	1020	1020	1040	1050
500	150	230	330	380	410	440	500	610	620	630	640	640	650	660
300	90	140	200	230	240	260	300	370	370	380	380	380	390	390
250	80	110	170	190	200	220	250	310	310	310	320	320	320	330
225	70	100	150	170	180	200	230	280	280	280	290	290	290	300
200	60	90	130	150	160	180	200	250	250	250	260	260	260	260
175	50	80	120	130	140	150	180	210	220	220	220	220	230	230

For ach hour of hauling time above 4 hours, reduce load by 4.0%
For each degree F above 52, reduce load by 5.6%
For each degree F below 48, increase load by 5.6%

TRUCK LOADING/HAULING DENSITY TABLE

by species and by operating capacity of truck

Coho

Note: **Table is based upon 4 hours hauling time and water temperature of 48 F to 52 F.**

F/lb / Oper gals	3000	550	200	100	75.0	60.0	40.0	20.0	16.0	12.0	7.5	5.0	3.5	2.5
3000	900	1170	1650	2030	2430	2800	3600	3780	3780	3780	4050	4050	4050	4050
2900	870	1130	1600	1960	2350	2710	3480	3650	3650	3650	3930	3930	3930	3930
2800	840	1090	1540	1890	2270	2610	3360	3530	3530	3530	3810	3810	3810	3810
2750	830	1070	1510	1860	2230	2590	3300	3470	3470	3470	3740	3740	3740	3740
2700	810	1050	1490	1820	2190	2520	3240	3400	3400	3400	3670	3670	3670	3670
2600	780	1010	1430	1760	2110	2430	3129	3280	3280	3280	3520	3520	3520	3520
2500	750	980	1380	1690	2030	2330	3000	3150	3150	3150	3380	3380	3380	3380
2400	720	940	1320	1620	1940	2240	2880	3020	3020	3020	3260	3260	3260	3260
2300	690	900	1270	1550	1860	2150	2760	2900	2900	2900	3130	3130	3130	3130
2200	660	860	1210	1490	1780	2050	2640	2770	2770	2770	2990	2990	2990	2990
2100	630	820	1160	1420	1700	1960	2520	2650	2650	2650	2850	2850	2850	2850
2000	600	780	1100	1350	1620	1870	2400	2520	2520	2520	2700	2700	2700	2700
1900	570	740	1050	1280	1540	1770	2280	2390	2390	2390	2580	2580	2580	2580
1850	560	7m	1020	1250	1500	1730	2220	2330	2330	2330	2520	2520	2520	2520
1800	540	700	990	1220	1460	1680	2160	2270	2270	2270	2450	2450	2450	2450
1500	450	590	830	1010	1220	1400	1800	1890	1890	1890	2030	2030	2030	2030
1000	300	390	550	680	810	930	1200	12.60	1260	1260	1350	1350	1350	1350
900	270	350	500	610	730	840	1080	1130	1130	1130	1220	1220	1220	1220
800	240	310	440	540	650	750	960	1010	1010	1010	1080	1080	1080	1080
500	150	200	280	340	410	470	600	630	630	630	680	680	680	680
300	90	120	.170	200	240	280	360	380	380	380	410	410	410	410
250	80	100	140	170	200	230	300	320	320	320	340	340	340	340
225	70	90	120	150	180	210	270	280	280	280	310	310	310	310
200	60	80	110	‘140	160	190	240	250	250	250	270)	« « I	270	270
175	50	70	100	120	140	160	210	220	220	220	240	240	240	240

For each hour of hauling time above 4 hours, reduce load by 4.0%
For each degree F above 52, reduce load by 5.6%
For each degree F below 48, increase load by 5.6%

TRUCK LOADING/HAULING DENSITY TABLE

by species and by operating capacity of truck

Rainbow and Cutthroat Trout

Note: Table is based upon 4 hours hauling time and water temperature of 48 F to 52 F.

F/lb	3000	550	200	100	75.0	60.0	40.0	20.0	16.0	12.0	7.5	5.0	3.5	2.5
Oper gals														
3000	1200	2400	2850	3000	3300	3600	3600	3900	4230	4560	4890	4890	4890	5100
2900	1160	2320	2760	2900	3190	3480	3480	3770	4090	4410	4730	4730	4730	4930
2800	1120	2240	2660	2800	3080	3360	3360	3640	3950	4260	4560	4560	4560	4760
2750	1100	2200	2610	2750	3030	3300	3300	3580	3810	4200	4500	4500	4500	4680
2700	1080	2160	2570	2700	2970	3240	3240	3510	3810	4100	4400	4400	4400	4590
2600	1040	2080	2470	2600	2860	3120	3120	3380	3670	3950	4240	4240	4240	4420
2500	1000	2000	2380	2500	2750	3000	3000	3250	3530	3800	4080	4080	4080	4250
2400	960	1920	2280	2400	2640	2880	2880	3120	3380	3650	3910	3910	3910	4080
2300	920	1840	2190	2300	2530	2760	2760	2990	3240	3500	3750	3750	3750	3910
2200	880	1760	2090	2200	2420	2640	2640	2860	3100	3340	3590	3590	3590	3740
2100	840	1680	2000	2100	2310	2520	2520	2730	2960	3190	3420	3420	3420	3570
2000	800	1600	1900	2000	2200	2400	2400	2600	2820	3040	3260	3260	3260	3400
1900	760	1520	1810	1900	2090	2280	2280	2470	2680	2890	3100	3100	3100	3230
1850	740	1480	1760	1850	2040	2220	2220	2410	2610	2810	3020	3020	3020	3150
1800	720	1440	1710	1800	1980	2160	2160	2340	2540	274-0	2930	2930	2930	3060
1500	600	1200	1430	1500	1650	1800	1800	1950	2120	2280	2450	2450	2450	2550
1000	400	800	950	1000	1100	1200	1200	1300	1410	1520	1630	1630	1630	1700
900	360	720	860	900	9900	1080	1080	1170	1270	1370	1470	1470	1470	1530
800	320	640	760	800	880	960	960	1040	1130	1220	1300	1300	1300	1360
500	200	400	480	500	550	600	600	650	710	760	820	820	820	850
300	120	240	290	300	330	360	360	390	420	460	490	490	490	510
250	100	200	240	250	280	300	300	330	350	380	410	410	410	430
225		180	210	230	250	270	270	290	320	340	370	370	370	380
200	80	160	190	200	220	240	240	260	280	300	330	330	330	340
175	70	140	170	180	190	210	2101	2301	250	270	290	290	290	300

For each hour of hauling time above 4 hours, reduce load by 4.0%
For each degree F above 52, reduce load by 5.6%
For each degree F below 48, increase load by 5.6%

Appendix D

Evaluation Guidelines

TYPES OF EVALUATIONS

Hatchery evaluations can be conducted from either a hatchery perspective or a fishery management perspective. Studies conducted from a fishery management perspective are generally directed at determining the contribution of a fish stock to a management unit, and that management unit's contribution to a particular fishery. Major objectives associated with these fishery contribution studies include:

- Requirements for evaluating and improving management programs.
- Developing guidelines that define the geographical area and identify component stocks (hatchery and/or wild) that comprise the management unit.
- Developing guidelines that define if the proper stocks of fish are currently being used.
- Determining which management units contribute to a specific fishery and the time periods of those contributions.
- Determining the relative contributions of the various management units to a specific fishery over the different time periods.

Studies conducted from the hatchery perspective are designed to assess the contribution and distribution of a defined group of fish to the fisheries, and to the escapement in which they appear. Specific objectives may include determining:

- To what fisheries and at what time **a** defined group of fish contributes.
- The contribution of a defined group of fish to the total fishery.
- The absolute (numerical) or relative (proportional) contribution of a defined group of fish **to a specific** fishery.

In addition to fishery management evaluations, specific hatchery evaluations are used to determine:

- Extent of meeting hatchery management and mitigation goals
- Extent of smolt survival rates
- Extent of straying
- Requirements for improving operational practices
- Extent of impacts of releasing hatchery stocks-on wild stocks
- Selective harvest
- Broodstock identification

SAMPLING PROCEDURES

Recommended procedures for the sampling and handling of fish during tagging are provided in the sections below.

Sampling Devices

It is critical that the tagged fish be representative of the defined group. Therefore, the sampling device should give each fish an equal or known chance of being selected for marking (Vreeland 1990). Types of sampling include:

1. Incline plane
2. Incremental (Foster 1981)
3. Sectional net/tub (Hewitt and Burrows 1948)

Representative Sampling Procedures

Procedures should be followed to ensure that sampled fish are representative of the entire group, and that the information obtained is precisely estimated.

1. Each pond or raceway containing the defined group of fish should be representatively sampled. The same proportion of fish should be randomly sampled from each pond.

2. If it is not possible to sample from all ponds containing the defined group then:

   - Avoid sampling from a single pond because substantial differences have been noticed among returns from seemingly identical rearing ponds.

   - Randomly select more than one pond, from all those containing the defined group, by using random number tables.

Treatment of Fish at Tagging

Each agency should adhere to its established procedures for fish handling and treatment during tagging. The following factors should be considered as part of tagging efforts:

1. Tag all fish sampled for tagging, even those exhibiting low quality. This ensures that the sampled fish are truly representative of the entire group.

2. Fish should be tagged prior to smoltification.

3. The choice of tagging time should. take the following factors into account to maximize fish survival and tag retention:

   - Fish size (i.e., fish should be as large as possible for the given species and experimental objectives)

   - Water temperature (i.e., colder water temperatures preferable)

   - Fish health

   - The potential of recovery from stress of handling, tagging, and fin clipping

- After the fish are tagged, they should be returned to the same pond from which they were sampled to ensure that their post-tagging management is representative of the entire defined group.

- A periodic process review by the operating agency should be scheduled

4. Certain characteristics (e.g., tag loss and size at release) of the release group must be measured after tagging is completed. Preferably this is done just before release of the fish. Sampling is required to estimate these parameters.

5. The estimated total number of fish released from a given group may be the single most important source of error in estimating contribution. Therefore, rigorous procedures must be developed and followed to assess the number of released fish and to determine whether the tagged fish are representative of the total release.

6. There should be an actual count of the total number of fish and the total number of tagged fish released. To minimize handling of "smolting" fish, they should be counted within two months of release if certain procedures and facilities are in place (i.e., bird predator protection measures, enumerating daily fish mortality, etc.).

7. Actual counts do not eliminate all sources of error. Marker errors can occur when the person tagging the fish fails to properly clip the adipose fins. If this is a major source of bias, sampling procedures should be established to estimate this error. Otherwise these fish may not be identified in the recovery program using current technology.

8. Another potential source of error-could exist if interpenetrating samples were taken. An actual count of tagged fish released would not distinguish among tag codes for the different samples, therefore actual counts could be used accurately only if the expected mortality and tag loss were the same for each tag code. This should be the case if the appropriate procedures are followed. If uncertainty exists, then the numbers of fish released should be estimated separately for each tag code.

9. When estimating total fish released using weight samples, a minimum of five samples should be taken, spaced over the time

of release or over ponds if samples are taken prior to release. Equipment for measuring weight or volume of samples for total release should be calibrated whenever used. Calibration problems are a major concern for volumetric measuring devices.

Marking Techniques

Standards for Marking Juvenile Fish

Fish marking for monitoring and evaluation purposes is a still an evolving science. There are three general types of marks currently used-immediate visual, immediate specialized, and delayed detection. These marks are distributed among juveniles and adults without regard to time of marking.

Techniques that have been identified for marking large groups of juvenile fish are listed below. Not all marks produce satisfactory results in terms of being permanent, and some marks have associated mortality impacts.

Immediate Visual Detection Marks

1. Fin clips (adipose ventral)
   - Adipose fin clip
   - Rayed-fin clip

2. Visual Implant Tags ("V.I." tags; include florescent tags)
   - V.I. Alpha-numeric tags
   - V.I. Elastomer injection tags
   - V.I. Florescent filament tags

3. Branding
   - Cold
   - Hot
   - Easer

Immediate Specialized Detection Marks

1. Body area tagging blank (CWTs)
2. Florescent sprays
3. PIT tags

Delaved Detection Marks

1. CWT + Adipose fin clip
2. Elemental marks
3. Otolith banding
4. Genetic marks

Performance Standards for *Evaluations*

There are several different types of evaluations that can be used in conjunction with fish marking efforts. These evaluations can help:

- Differentiate hatchery fish
- Protect wild and natural fish
- Identify broodstock
- Identify CWT- and PIT-tagged fish
- Provide for selective fish harvests

Other than segregating wild/natural fish (unmarked) from marked hatchery fish, few marks can be used to identify the fish's origin without killing the fish. The PIT tag is an example of an exclusive mark that provides immediate knowledge of **the** animal's origin. However, its use requires technical equipment and does not allow the layman to immediately determine the origin of the fish.

Variations in external marks limit the number of sources that can be covered. It is critical that additional research and development be conducted to establish adequate methods of fish identification. Statistical evaluation of projects may follow standards analysis **with** each project being dependent on its design and variation.

Standards for *Marking Adults*

Marks used to identify adults captured **on** their return to the spawning grounds or hatchery are listed below. As with juveniles, the marks produce mortality and are limited in their application. Although they are best applied after fish reach a weir, or are **captured** for broodstock, they have also been used for "in-the-field" research.

- **Floy** tags
- Disc tags
- Jaw tags
- Opercle punch
- Fin clips

Analysis

Appendix Table D-l compares the suitability of different mass marks for different management purposes. Some generalizations can be made from the information presented in this table.

1. No one mark will satisfy all-management and research needs.

2. "Immediate visual detection*' marks are necessary for management objectives that require identification of hatchery fish by fishers. These marks include adipose clip, the ventral clip, and the V.I. florescent tags (not yet perfected).

3. Numerous marks are available if management objectives are limited to distinguishing between hatchery and wild fish, or separating stocks at a hatchery or weir. These include both "immediate visual" and "immediate specialized" detection marks.

4. If management objectives involve analyzing the stock composition of marine fisheries, "delayed detection" techniques (involving sacrificed or harvested fish) are currently required. If management objectives are limited to analyzing stock composition in terminal areas, other types of marks may also be an option.

A cost comparison between the various marking techniques is presented in Appendix Table D-2.

Appendix Table D- 1. Comparison of Management Purposes and Potential Mass Marks

Management Purpose	Immediate Visual Detection Marks			Immediate Specialized Detection Marks			Delayed Destructive Detection Marks			
	Fin Clips	VI Tags	Branding	Body Area Wire Tag	Fluorescent Sprays	PIT	CWT + Adipose	Elemental	Otolith	Genetic
Broodstock Management	Yes	Yes	No	Yes	No	No	Yes	No	No	No
Selective Harvest	Yes	Yes	No	No	No	No	Yes	No	No	No
Identify Hatchery/Wild Fish Passing Check Points or on Spawning Grounds	Yes	Yea	Juveniles	Yes	Juveniles	Yes	?	No	No	No
Fishery Stock Composition Estimates	limited	limited	No	Limited	Limited	Yes	Yes	Yes	Yes	Yes
Distribution/Migration/Timing Patterns	limited	limited	?	Limited	limited	?	Yes	Limited	Limited	Limited
survival Estimates	No*	No*	No	No*	No	?	Yes	No*	No*	No
Harvest Rate Evaluations	Limited	Limited	No	Limited	No	?	Yes	Limited	Limited	limited

Key: **Yes** = **Mark is suitable for purpose**
No = **Mark is unsuitable for purpose**
? = **Mark suitability dependent on tagging and sampling programs**
Limited = **Mark suitability** limited to **terminal situations and/or** with **limited** stock resolution
Juveniles = **Mark** suitability limited to juvenile life **stages**
* = **Mark** may **have suitability** for **steelhead** with **terminal-only fisheries**

Table taken from: Mass Marking Anadromous Salmonids
Report **from PSMFC Subcommittee on** Mass Marking
The Regional **Mark Committee**

Appendix Table D-2. Comparison of "Mass" Marks

	Mark	Application		Mark Characteristics				Direct Costs	
		Rate	Min. Size	Mortality	Detectability	Stability	Level of ID	Application (per 1,000 fish)	Decoding Costs/Fish (sampling not included)
Immediate Visual	1a Adipose Fin Clip	800/person/hr @ 90/lb, 80mm	Emergent fry	Low	Immediate - visual	Permanent	Dichotomous (62.. yes or no)	$25 - with trailer $15 - on station	Zero
	1b Ventral Fii Clip	650/person/hr @ 90/lb, 80mm	Emergent Fry	Variable	Immediate - visual*	Semi-permanent (some regeneration)	Limited groups	$28 - with trailer $16 - on station	Zero
	2a VI Alpha-numeric tags	300/person/hr @ 20/lb, 115mm	30/lb, 115mm*	Low	Immediate - visual	Permanent*	Limited groups	$300	Zero
	2b VI Elastomer Injection	400/person/hr @ 90/lb, 80mm	150/lb, 70mm*	Low	Immediate - visual (enhanced by UV light)	Permanent*	Limited groups	$110 - with trailer	Negligible
	2c VI Fluorescent Filament Tag	400/person/hr @ 50/lb, 100mm	60/lb, 90mm*	Low	Immediate - visual (enhanced by UV light)	Permanent*	Limited groups	$110 - with trailer	Negligible
	3 Branding	700/person/hr @ 90/lb, 80mm	225/lb, 60mm	Low	Immediate - visual	Semi-permanent, unreliable over time	Limited groups	$26	Zero
Immediate Specialized	4 Body Area Wire Tags	400-700/person/hr @ 90/lb, 80mm	150/lb, 70mm*	Low	Magnetic detection	Permanent	Limited groups	$62 - with trailer	Negligible (initial equipment costs)
	5 Fluorescent Sprays	10,000's/hr	225/lb, 60mm	Low	Visual (with UV light)	Semi-permanent (dissipates over time)	Limited groups	$Low	Low
	6 PIT Tags	100/person/hr @ 90/lb, 80mm	170/lb, 65mm*	Low	Immediate, Electronic detection	Permanent, no time of spawning	Individual fish	$4,000	(Initial equipment costs)
Delayed Detection	7 CWT & Adipose Fin Clip	450/person/hr @ 90/lb, 80mm	Full length: 225/lb, 60mm Half length: Emergent fry	Low	Immediate - visual, Magnetic detection; Microscopic decoding	Permanent	Individual release groups	$106 - with trailer	$5
	8 Elemental Marks	Unlimited	Emergent fry	Negligible	Delayed Identification, Mass spectrometry	Permanent	Limited groups	Low	$20/sample
	9 Otolith Banding	Unlimited	Eyed eggs	Negligible	Sacrifice fish Delayed Identification, Microscopic	Permanent	Limited groups	Low (initial equipment costs)	$10/sample (initial equipment costs)
	10 Genetic Marks	Natural mark or requires initial selective breeding	N/A	Negligible	Sacrifice fish, Delayed Identification, Electrophoretic analysis	Permanent	Stock groups, individual ID not possible	Natural: negligible Selective: high initial costs	$12/sample

*Needs Research

Table taken from: Mass Marking Anadromous Salmonids
Report from PSMFC Subcommittee on Mass Marking
The Regional Mark Committee