



PRINCIPLES AND SYSTEM-WIDE RECOMMENDATIONS

Over the period of this project, the HSRG has developed a thorough understanding about applying existing science to hatchery management. After three years of regional reviews, the HSRG concluded that while any individual program may be successful in broodstock collection, rearing or other operational considerations, it may still be operating in a manner that does not, for example, adequately take into account risks to other stocks or to the environment, maximize benefits to the target stock, or consider whether adequate habitat will be available over time for the fish it produces.

In each region, the HSRG found:

- If the goals for each stock (conservation, harvest, research, education, etc) were clearly understood by the hatchery operator, the ability to evaluate the benefits and risks of a hatchery program was greatly improved;
- A clearly articulated, scientific rationale for a hatchery program can provide the managers with a science-based foundation for decision making and a range of scientific tools and strategies for achieving goals; and
- Hatchery managers who were able to measure the contribution of a hatchery program toward a particular resource goal had a greater chance of achieving that goal.

Based on these observations, the HSRG developed three principles, based on principles of good natural resource management, to guide the use of hatcheries. These principles include: 1) Well-Defined Goals, 2) Scientific Defensibility, and 3) Informed Decision Making. The HSRG also assembled system-wide recommendations (applicable to programs across the Puget Sound and coastal Washington hatchery system) that serve as hatchery based strategies for achieving these principles. Just as the program-specific recommendations were developed for each hatchery program, system-wide recommendations were developed for hatcheries collectively.

These principles and recommendations are presented here to help guide the managers as they implement hatchery reform, and to help answer how hatcheries can serve as tools for recovering naturally-spawning salmonid populations and providing sustainable fisheries.

Principle 1: Well-Defined Goals

Goals for all affected stocks must be well-defined. These goals should be quantified, where possible and expressed in terms of values to the community (harvest, conservation, education, research, employment, recreation, etc.). Hatcheries can then be managed as tools to help meet those goals. The



HSRG's scientific framework¹⁷ outlines the issues involved with, and conditions required for, hatcheries to be an appropriate contributor to meeting harvest, conservation or other goals.

Harvest and conservation were the most common stock goals encountered by the HSRG. They can be defined as follows:

- Harvest goals promote commercial, subsistence, ceremonial, and recreational fishing
- Conservation goals promote the conservation of indigenous salmonid resources. They include endangered species protection and recovery, gene banking, maintaining native stocks for which natural spawning habitat is lost, and restoring stocks to streams where they have been extirpated.

The HSRG observed that goals for the fish resource were not always explicitly communicated and/or fully understood by the managers and operators of hatchery programs. To be successful, hatcheries should be used as part of an integrated strategy where habitat, hatchery management and harvest are coordinated to best meet resource management goals defined for each stock in the watershed. Hatcheries are by their very nature a compromise, a balancing of benefits and risks to the target stock, other stocks and the environment affected by the hatchery program. The use of a hatchery program is appropriate when benefits significantly outweigh the risks, and when the use of a hatchery program is more favorable than the benefits and risks associated with non-hatchery strategies for meeting the same goals.

The HSRG has developed the following **system-wide recommendations** to help ensure a comprehensive goal setting process.

Set Goals for all Stocks and Manage Hatchery Programs on a Regional Scale

Early in the project, the HSRG and the managers agreed that hatchery programs must be evaluated in the context of the regions and watersheds in which they operate and the goals set by the managers. In designing the review process, the HSRG determined that a review of Puget Sound and coastal hatcheries and their programs as a whole would have led to broad generalities not suited to regional differences in stock and habitat status. Similarly, a hatchery-by-hatchery review would not have allowed for evaluation in the context of each region's current and future habitat, harvest goals, the status of all regional, anadromous salmonid stocks, and the cumulative effects of all regional hatchery programs. The HSRG recommends that the managers continue this regional approach to reviewing and setting goals, managing hatchery programs, and implementing the principles and recommendations. The HSRG further recommends that implementation of hatchery reform recommendations be coordinated by regional technical groups, to ensure that goals for the resource and the role of each hatchery program in achieving those goals are tracked. These regional bodies may currently be in existence or may be patterned after the regional participant lists generated for the HSRG's regional review process.

¹⁷ See Appendix A, *Scientific Framework*.



Measure Success in Terms of Contribution to Harvest, Conservation and Other Goals

The HSRG recommends that the managers measure hatchery contributions to harvest opportunity, the conservation of genetic resources, and other goals for salmon and steelhead populations. It is not uncommon for the direct hatchery output (i.e., numbers or pounds of juveniles released) to be cited as the goal by which a program's success is measured. More appropriate measures of success include:

- The scale and availability of harvest provided.
- The number of returning adults and their ability to reproduce and sustain the stock.
- The relative risks and benefits of each hatchery program.
- Alternative strategies for meeting similar goals.
- Whether the program is part of a comprehensive strategy to meet a stated resource goal.

Have Clear Goals for Educational Programs

The HSRG strongly supports the many educational programs conducted at, or supported by, hatchery facilities across Puget Sound and coastal Washington. These programs are valuable for educating the public on the biology of salmon, the importance of maintaining healthy salmon habitat, and sustainable fisheries.

A clear understanding of a program's specific educational goals needs to be articulated, along with methods for determining if those goals are being met and for reporting educational benefits. It is incumbent upon the fisheries managers, as the professional partners of these often volunteer-driven programs, to ensure that such goal statements are developed for these programs and understood by participants. It is also essential that these programs be operated consistent with the conservation principles they are intended to promote.

Principle 2: Scientifically Defensible Programs

Once the goals for the resource have been established (see above), the scientific rationale for a hatchery program – in terms of benefits and risks - must be spelled out to explain how the hatchery program expects to achieve its goals. The purpose, operation, and management of each hatchery program must be scientifically defensible. The strategy chosen must be consistent with current scientific knowledge. Where there is uncertainty, hypotheses and assumptions should be articulated. In general, scientific defensibility will occur at three stages: (1) during the deliberation stage to determine whether a hatchery should be built and/or a specific hatchery program initiated; (2) during the planning and design stage for a hatchery or hatchery program; and (3) during the operations stage.

This approach ensures a scientific foundation for hatchery programs, a means for addressing uncertainty, and a method for demonstrating accountability. Documentation for each program should include citations from the scientific literature and models that take into account the various factors



(e.g., predation assumptions, cumulative effects, etc.). The scientific framework, the Benefit/Risk Tool and the operational guidelines developed by the HSRG to guide the regional review process all provide resources for ensuring scientific defensibility for hatchery programs (see appendices).

The HSRG has developed the following **system-wide recommendations** to help ensure a scientifically defensible hatchery program.

Operate Hatchery Programs within the Context of Their Ecosystems

The benefits and risks of hatchery programs can only be properly evaluated in the context of their ecosystems. Hatchery management requires understanding interactions between species and in particular, managing the risk of negative interactions. This requires knowing the status of the hatchery stocks and of other stocks, understanding the interactions between the stocks, and how well the habitat can support these stocks now and in the future.

The release of hatchery fish into the environment will affect the ecosystem. While these effects are not fully predictable, information about, for example, competitive and predatory relationships among species is available to help avoid unwanted outcomes.

Each ecosystem is unique, based on its history, natural events, (human) land use, and the strategies and goals developed by resource managers. The status and expectation for naturally-spawning stocks and the environment prescribe the potential for success and the limitations on any hatchery program. Therefore, in making decisions about current and future hatchery programs, decision makers should have current and future habitat assessments available to them in order to make informed decisions about goals for other stocks.

Operate Hatchery Programs as either Genetically Integrated or Segregated Relative to Naturally-Spawning Populations¹⁸

Hatchery broodstocks should be managed as either genetically integrated or genetically segregated. Hatchery programs are classified as *integrated* if a principal goal is to manage the broodstock as an artificially propagated component of a naturally spawning population. In contrast, hatchery programs are classified as *segregated* if the management goal is to propagate the hatchery broodstock as a discrete or genetically segregated population, relative to naturally spawning populations.

In this context, “intermediate” programs cannot exist without potentially posing significant risks to natural populations. The concepts of genetic integration and segregation, as they relate explicitly to hatchery programs, lead to well-defined operational guidelines and objectives for achieving the respective broodstock management goals while minimizing risks to naturally spawning populations. Each concept provides a template for broodstock management and operations. The

¹⁸ See Appendix A, *Scientific Framework, Applied Hatchery Reform-Regional Review Process, and, Emerging Issues paper on integrated and segregated programs.*



greater the deviation from one of these templates, the greater are the risks to naturally spawning populations with increased likelihood that the benefits of a hatchery program will not outweigh the risks. Consequently, from the outset, each hatchery program must identify one of the two broodstock strategies and follow that strategy as closely as possible to achieve the desired purpose of the program.

Integrated Program – A hatchery program is of an integrated type if the intent is for the natural environment to drive the adaptation of a composite population of fish that spawns both in a hatchery and in the wild. A fundamental goal of an integrated program is for the hatchery broodstock to be as similar genetically as possible to naturally spawning populations, in areas where fish are released and/or collected for broodstock. The long-term goal is to maintain genetic characteristics of a local, natural population among hatchery-origin fish, by minimizing genetic changes resulting from artificial propagation and potential domestication. In an idealized integrated program, natural-origin and hatchery-origin fish are genetically equal components of a common gene pool.

A hatchery supporting an integrated program can be viewed conceptually as an artificial extension of the natural environment where the population as a whole (hatchery + wild) is sustained at a much higher level of abundance than would occur without the hatchery. A properly managed integrated broodstock can potentially serve as a genetic repository in the event of a major decline in the abundance of natural-origin fish.

An integrated program does not imply that natural spawning of hatchery-origin fish is desired or even occurs. Natural spawning (a.k.a., supplementation) relates to the purpose, desired benefits and potential risks of a hatchery program and not to the genetic management goals for a hatchery broodstock, although the two sets of goals are usually correlated. Hatchery-origin fish spawning naturally does not make a hatchery broodstock genetically integrated—only if natural-origin fish are included in the broodstock in a systematic, prescribed manner can the broodstock be considered genetically “integrated.” In this context, the management goal of an integrated program is to maintain the genetic characteristics of naturally-spawning fish among hatchery-origin fish, not vice-versa.

Specific recommendations for integrated programs include:

- Develop a detailed, genetic management plan for the hatchery broodstock and the naturally spawning population in the watershed where adults are trapped for broodstock.
- Ensure that an average of 10–20% of the hatchery broodstock is composed of natural-origin adults each year.
- Collect and spawn adults randomly with respect to time of return, time of spawning, age, size and other characteristics related to fitness.
- Impose hatchery management practices that minimize the potential domestication effects of the hatchery environment.



- Use marks, tags or other methods to distinguish natural- and hatchery-origin fish among natural spawners, in hatchery broodstocks, and in harvests.
- Monitor and control natural spawning by hatchery-origin adults so that the percentage of natural spawners composed of hatchery-origin fish is significantly less than the percentage of the hatchery broodstock derived from natural-origin fish. This general rule may be violated in restoration supplementation programs where natural spawning by hatchery-origin adults is an intended purpose of the hatchery program.
- Adjust the size of integrated hatchery programs relative to the size of the naturally spawning population so that the number of natural-origin adults spawning naturally in a watershed is greater than the total number of adults required for broodstock.
- In order to avoid broodstock mining, the natural component of the hatchery broodstock should not cause the number of natural spawners to fall below the escapement goal for natural spawners.

Segregated Program - The fundamental goal of a segregated program is to propagate the hatchery broodstock as a discrete population or gene pool that is reproductively segregated from naturally spawning populations. Once established, segregated broodstocks are composed entirely of returning, hatchery-origin adults. As a consequence, genetically segregated hatchery populations can, and will, change genetically, relative to naturally spawning populations. Such changes may be intentional to maximize the desired benefits of the program, while minimizing risks to naturally spawning populations. However, in contrast to integrated programs, *any* natural spawning by hatchery-origin fish from a segregated program will impose potentially unacceptable risks to natural populations.

Specific recommendations for segregated programs include:

- Release and recapture fish in areas where opportunities to capture non-harvested adults are maximized, thus minimizing genetic risks to natural populations.
- Rear fish in a manner and/or at a location that minimizes potential straying and opportunities for natural spawning.
- Ensure harvest opportunities are commensurate with potential adult production from segregated programs and take into consideration the potential selective impacts of harvest on the long term viability of segregated programs.
- Ensure hatchery-origin adults constitute no more than one to five percent of natural spawners.
- Use marks, tags, or other methods to distinguish natural- and hatchery-origin fish among natural spawners, in hatchery broodstocks, and in harvests.



- Avoid trapping natural-origin adults, and exclude them from the broodstock.

Size Hatchery Programs Consistent with Stock Goals

Fisheries managers should determine the proper size (number of fish released) of a hatchery program based on clearly defined goals established for the stock. The size of hatchery program must consider two parameters: (1) the number of released fish to meet the purpose of the program and (2) the number of adult spawners necessary to meet *both* the purpose of the program *and* the genetic management goals for the broodstock. In general, the number of fish released should be the smallest number necessary to meet the management goal of the program. In addition, the number and composition (hatchery- or natural-origin) of adults used for broodstock must meet genetic guidelines and constraints consistent with maintaining a viable population.

Hatchery programs that are sized incorrectly present ecological and economic risks. For example, large hatchery releases may interact through competition and predation with natural stocks and other ecological processes in a detrimental way. These “extra” fish may also impact the survival of other populations once they enter the ocean. Resources spent producing these fish may be wasted if returning adults cannot be harvested and/or overwhelm hatchery workers.

Consider both Freshwater and Marine Carrying Capacity in Sizing Hatchery Programs

Freshwater and marine trophic conditions and carrying capacity may limit the ability of a program to contribute to a resource goal.¹⁹

For example, stocks of coho and Chinook have shown a decrease in survival over the past decade in certain regions of Puget Sound and the coast, such as southern Puget Sound. The decrease may be related to the general decline in productivity of inland, marine waters. There has been a great deal of speculation as to additional cause(s) for the decline in these regions, (e.g., increased bird and marine mammal predation; a general lowering of water quality from urbanization in a body of water with low turnover; continuing loss of freshwater habitat, a shift in the forage base, etc). Whatever the cause, the trophic capacity of southern Puget Sound to support salmonid fishes appears to have diminished in recent years.

Lowered survival may also be related to the total biomass of salmonids presently being released from hatcheries, despite recent reductions in the actual numbers of fish released. Closure of certain unproductive hatcheries and reduced production at other hatcheries may in fact benefit the quality and survival of both naturally spawning and hatchery fish.

Factors that should be considered in sizing a hatchery program may include (but not be limited to) the following:

1. the potential for ecological interactions with natural populations;

¹⁹ See HSRG Scientific Framework and Hatchery Review Program, *Emerging Issues chapter, section on marine carrying capacity.*



2. the physical capacity of the individual hatchery;
3. the carrying capacity of receiving waters in terms of both juveniles and adults (see recommendations above);
4. changes in ocean productivity; and
5. the ability to control the contribution of hatchery-origin fish to the natural spawning escapement, (e.g., through selective harvest).

Overall, the managers should maintain a repertoire of release strategies that can be adjusted in response to changing environmental or trophic conditions. There must be a defensible rationale for any given level of hatchery production, leading to sustainability and cost effectiveness.

Ensure Productive Habitat for Hatchery Programs

The HSRG has concluded that productive habitat, in which a salmon population conducts the various phases of its life cycle, is necessary to the success of any hatchery program. The fitness of the naturally-spawning population, its productivity, and the number of adult salmon (artificially or naturally produced) returning to the watershed ultimately depend on the natural habitat, not on the output of the hatchery. Silt free incubation gravels and cool, stable incubating water are necessary for the survival of salmon embryos. Flowing streams with complex structure, riparian vegetation, seasonal flow stability, and productive estuaries are necessary to the survival of juvenile salmon. Flowing streams are also necessary for the successful passage and spawning of returning adults.

In particular, habitat is essential to the success of integrated hatchery programs because the hatchery broodstock is directly supported genetically and demographically by the naturally spawning component.²⁰ Integrated hatchery programs will be limited in scope by the productivity of the natural habitat. Natural populations are expected to increase in fitness and productivity as habitats improve. In addition to the habitat described for all programs, silt free incubation gravels and cool reliably stable irrigating water are necessary for the survival of salmon embryos.

Emphasize Quality, Not Quantity, in Fish Releases

Release the lowest number of fish (consistent with goals for the resource) with the highest quality to maximize potential benefits while minimizing risks to naturally spawning populations. The HSRG's working model is that the best a hatchery program can expect to do is to match a wild salmon template in terms of the physiological, morphological and behavioral traits that affect smolt-to-adult performance. Measures of quality can include affects on physiological, morphological and behavioral fitness, including competency of juvenile fish to migrate, establish territory, and displace other individuals, prey and forage.²¹ These fitness characteristics clearly have both genetic and environmental components (nature vs. nurture).

²⁰ See HSRG System-wide Recommendation on Integrated and Segregated broodstock management

²¹ See Emerging Issues paper "Hatchery Smolt Quality and Achieving the Wild Salmon Template" in Appendix B.



It is important that some measure of the quality, rather than simply the quantity, of fish released from hatcheries be measured and evaluated. In the past, performance has been measured by numbers of juveniles released. As discussed in the recommendation to “Size Hatchery Programs Consistent with Stock Goals,” releasing too many fish may have ecological risks and economic costs. In the future, performance should be measured by the level of post-release survival and the rate of adult returns, both of which depend on the quality of the fish released.

Use In-Basin Rearing and Locally-Adapted Broodstocks

Some hatchery programs, for lack of adequate facilities and/or proper escapement management, transfer eggs and/or juveniles between facilities and among watersheds/regions. The HSRG recommends that “backfilling” of broodstock shortages should be terminated. Managers should use in-basin rearing and locally adapted broodstocks to increase the productivity of hatchery programs and minimize risks. Failure to do so results in a loss of local genetic adaptability, increased potential for disease transfer, and lowered productivity of hatchery stocks. This practice of importation and movement of eggs and juveniles into and out of the region should thus be ended.

Spawn Adults randomly throughout the Natural Period of Adult Return

The HSRG recommends that the managers adopt and implement policies that conserve or recover natural life history traits of the various hatchery stocks to assure long-term sustainability. There can be loss of certain life history traits in hatchery stocks through the process of domestication. An example is the shift in spawn timing resulting from selective breeding for early adult return.

Use Genetically-Benign Spawning Protocols that Maximize Effective Population Size

The HSRG recommends that the mating of hatchery fish should be designed to achieve two principal objectives: 1) maximizing the genetic effective number of breeders; and 2) ensuring that every selected adult has an equal opportunity to produce progeny (i.e. avoid selective breeding and artificial selection in the hatchery environment). This is particularly critical in conservation programs, where populations are small or have experienced significant declines.

To achieve these objectives, male and female hatchery fish can be mated following pairwise (one male to one female), nested (e.g., one male to three females), or factorial (e.g., three-by-three spawning matrix) designs. Mixed milt spawning where eggs are fertilized by the simultaneous or sequential addition of sperm should be avoided because of unequal genetic contributions among male spawners and consequential reductions in effective population size.



During its review of hatchery programs, the HSRG has seen a variety of spawning protocols, including modified factorial mating,²² single family pairing, as well as protocols that pool gametes prior to fertilization. The approaches of single family mating and modified factorial mating have proven to be feasible and effective (up to 94% fertilization), even in some of the largest programs reviewed (up to five million eggs taken per year). Because these methods achieve the two principle objectives and can be implemented relatively easily, the HSRG recommends that all programs, up to the size noted, adopt one of these protocols.

Hatchery spawning protocols prescribed by the managers typically incorporate gametes from all age classes, including jacks (early returning males), to maintain genetic continuity or gene flow among brood years within populations. A common approach by the co-managers is to use jacks for 2% of the adult male spawning population. This rate is probably lower than what occurs among natural spawning populations. The HSRG therefore recommends that jacks be spawned according to their occurrence among returning adults up to a maximum of 10%, with the exception of coho salmon where a *minimum* of 10% jacks among male spawners should be used. The inclusion of jacks to maintain genetic continuity among brood years of coho is especially important, because they mostly mature at three years of age.²³

Reduce Risks Associated with Outplanting and Net Pen Releases

Releasing smolts in streams geographically removed from a hatchery or adult collection facility is commonly called outplanting. This practice may pose significant genetic risks by promoting stray rates, often exceeding natural levels, to freshwater areas where interbreeding with naturally spawning populations is undesirable.

Steelhead programs in Puget Sound and coastal Washington have often used outplanting to support sport fisheries in a large number of small streams. Similarly, saltwater net pens are used to acclimate and release salmon smolts in marine areas where a targeted marine fishery on returning adults is desired. A common feature of these programs is that they release fish where no facilities exist to trap returning adults that escape target fisheries. Outplanting and net-pen releases from segregated hatchery programs²⁴ are especially problematic, because of the potentially high level of genetic divergence between the hatchery stock and natural populations where straying and natural spawning may occur.

The HSRG recommends reducing risks associated with outplanting and net-pen releases by reducing the number and/or size of such programs. Risks can also be reduced by:

- 1) intense, selective harvest and/or the use of adult traps;
- 2) implementing the HSRG's system-wide recommendations for steelhead, to substantially reduce the geographic range of outplanting;

²² Currens, K.P., J.M. Bertolini, C.A. Busack, and J. Barr. 1998. *An Easier Way to Meet Genetic Spawning Guidelines*. Pages 41-44 in *Proceedings of the 49th Pacific Northwest Fish Culture Conference*, Boise, ID

²³ Van Doornik, D.M., M.J. Ford, and D.J. Teel. 2002. *Patterns of temporal genetic variation in coho salmon: estimates of the effective proportion of two year-olds in natural and hatchery populations*. *Transactions of the American Fisheries Society*. 131: 1007-1019

²⁴ See recommendation above on operating integrated and segregated hatchery programs.



- 3) restricting release to areas where adult collection facilities are available or can be easily developed;
- 4) using locally-adapted and integrated stocks²⁵ in net pens, so that strays have less of a deleterious effect on natural populations;
- 5) evaluating the benefits and risks of each program every two or three years, and reducing or terminating programs that impose significant risks relative to benefits;
- 6) monitoring and evaluating high risk programs to ensure that adverse effects to naturally-spawning populations are minimal, straying risks are appropriately managed, and off-station releases are appropriately located; and
- 7) developing system-wide, risk management guidelines and protocols for outplanting and net-pen programs.²⁶

Develop a System of Wild Steelhead Management Zones (a special case)

Segregated hatchery steelhead programs are used extensively throughout Puget Sound and coastal Washington to provide a harvest opportunity. These segregated steelhead programs often outplant non-native stock with no provision for the recapture of returning adults. This is unlike segregated Chinook and coho hatchery programs, which release fish directly from the hatchery where the returning adults can be recaptured. The HSRG understands it is the intention of the managers to continue segregated steelhead programs into the future. In general, the HSRG believes that the widespread stocking and outplanting of steelhead smolts poses unacceptable ecological and genetic risks to naturally spawning populations, particularly in small streams that receive such outplants or to which hatchery-origin fish stray. The biggest concern is the genetic risk posed by the spawning overlap between the hatchery (Chambers Creek origin), early-timed winter run stock and the native, late-timed winter run stock.

The HSRG recommends that the managers develop a system of “wild steelhead management zones” where entire sub-regions or portions of watersheds for large rivers (e.g. Skagit River) are not planted with hatchery-origin fish but are managed for “wild” steelhead only. This approach will increase protection of native stocks in while still permitting harvest opportunities in areas where the genetic and ecological risks of hatchery releases are substantially less (e.g. where adult recapture facilities exist).

The HSRG recommends that wild steelhead management zones be developed for each of the ten regions within Puget Sound and coastal Washington. Harvest for steelhead may be compatible with this approach, but no hatchery-propagated steelhead would be introduced into the wild steelhead management zones. Such areas would reduce the risk of naturally spawning fish interbreeding with non-native hatchery fish, and provide native stocks for future fisheries programs. The streams selected should represent a balance of large and small streams, habitat

²⁵ *Ibid.*

²⁶ See *Emerging Issues, paper on out-planting and net pens.*



types, stock status, etc. Hatchery production may need to be increased in streams selected for hatchery harvest.

The HSRG acknowledges the need to promote segregated hatchery steelhead programs that are self-sustaining. Existing programs are based largely on steelhead of Chambers Creek origin winter and Skamania origin summer steelhead. These stocks have been transplanted to many locations throughout Puget Sound and coastal Washington. Once these segregated stocks have been transplanted they should be maintained as separate broodstocks now maintained with returning adults at those locations so they can adapt to the local environment.

When implementing a segregated steelhead program, it is important to minimize interaction with naturally spawning steelhead, through such tools as differential timing and a decision on benefits versus risks on outplanting in freshwater habitat. Adult collection procedures need to be incorporated to capture adults that are not harvested from the returning segregated population.

The HSRG recognizes the role integrated hatchery programs can serve for conservation or harvest, using native broodstocks. It is important to recognize the differences between integrated stock management, incorporating native origin broodstock, and segregated stock management, using non-native origin broodstock.²⁷

Monitoring and evaluation should be a basic component for streams managed for native stocks and those managed for hatchery harvest.

Use Hatchery Salmon Carcasses for Nutrifaction of Freshwater Ecosystems, while Reducing Associated Fish Health Risks²⁸

Returning adult salmon are a unique vector for the delivery of marine nutrients into the freshwater ecosystem. The importance of these nutrients to consumers such as raccoons, bear, eagles and even man has been recognized for some time. Recent research also suggests that a significant portion of nitrogen in plants and animals in streams where adult salmon are abundant is derived from those returning adults. Marine-derived nutrients from returning adult salmon have been found to make a significant contribution to riparian vegetation and even old-growth forests. In streams in interior British Columbia up to 60% of the nitrogen in benthic insects was derived from the carcasses in streams where salmon were abundant. They also found that juvenile salmon show higher growth rates in streams where adult salmon spawn than in streams without spawning adults. Use of hatchery salmon carcasses as a source of these marine-derived nutrients was found to increase the density of age 0+ coho and age 0+ and 1+ steelhead in small, southwestern Washington streams.

The deliberate distribution of hatchery salmon carcasses into watersheds for purposes of nutrifaction can have a positive ecological benefit to natural salmonid stocks. This practice may, however, also pose a fish health risk to these stocks if those carcasses carry live pathogens and are

²⁷ See System-wide Recommendation above on operating integrated and segregated hatchery programs.

²⁸ See Appendix B, Emerging Issue paper for references and more information on this topic.



not properly treated or managed prior to distribution. It is well recognized that disease organisms present in salmon carcasses can be transmitted to other salmonids following the release of these organisms into water or through their direct consumption unless appropriate disease risk-averse measures such as pathogen-free certification are followed.

Principle 3: Informed Decision Making

Assuming that goals for the resource have been established (see Principle 1), and the scientific rationale and defensibility for a particular hatchery program have been developed into a comprehensive *management and operational plan*, the HSRG further recommends that the managers' decisions be informed and modified by continuous evaluations of existing programs and by new scientific information. Such an approach will require a substantial increase in scientific oversight of hatchery operations, particularly in the areas of genetic and ecological monitoring.

With clear decision making processes in place that respond to new information, the HSRG believes that hatcheries can be managed in a more flexible and dynamic manner in response to changing environmental conditions, new scientific information, economic value of the resource, and other models where actions are evaluated and modified to determine the best use of limited resources.

This model applied to hatcheries requires that performance standards and indicators be identified so that monitoring activities will focus on key uncertainties and effective evaluation of results can occur. Results of the monitoring and evaluation (M&E) must then be brought forward to a decision making process in a clear and concise way so needed changes can be implemented. This responsive process should be structured to allow for innovation and experimentation so hatchery programs may be responsive to new goals and concepts in culture practice.

The HSRG has developed the following **system-wide recommendations** to help ensure the principle of informed decision making for hatchery programs is achieved.

Adaptively Manage Hatchery Programs

The HSRG recommends that adaptive management is particularly important in the context of hatchery reform. Adaptive management, as related to ecosystems, is defined as an “adaptive policy that is designed from the outset to test clearly formulated hypotheses about the behavior of the ecosystem being changed by human use.”²⁹ There is a significant amount of scientific uncertainty about the effects and proper uses of hatcheries, and a great need for flexibility and adaptation to changing goals, new scientific knowledge, and new information about the condition of stocks and habitat. A structured adaptive management program will be a key component of a strategy for success in these circumstances.

A critical implication is the notion of responsive change—rather than the status quo—as the normal operating procedure. Put simply, adaptive management is learning by doing, assuming

²⁹ Lee, K. N. 1993. *Compass and gyroscope: integrating science and politics for the environment*. Island Press, Washington, DC.



your program and operations will change regularly to reflect new information and better meet goals, and taking action in the face of scientific uncertainty. However, the actions taken through adaptive management are not selected at random. Rather, action is prescribed through the thoughtful and disciplined application of the scientific method.

The scientific method and adaptive management require a scientific framework for organizing and understanding information and identifying uncertainties. The HSRG has developed such a framework for the context of anadromous salmonid hatcheries³⁰ and encourages the managers to use this framework and keep it up to date. Equally important is a structured process that assures the right information is collected, analyzed, reported and brought forward in the decision making processes at all levels of hatchery operation. The HSRG encourages the managers to adopt an adaptive management approach to implementing hatchery reform, and offers both the tools it has developed for the regional review process, and the experience it has acquired during the review process, to aid the managers in their creation of this approach.

Incorporate Flexibility into Hatchery Design and Operation

The HSRG recommends that facilities be designed and operated in such a way that they are able to respond relatively easily to changes in harvest and conservation goals and priorities, ocean carrying capacity, stock status, freshwater habitat conditions, and the myriad other factors that will alter current policies and programs. The goal of a hatchery or regional manager should *not* be to “fill the hatchery facility to its biological capacity,” but rather, to manage the facility to achieve programmatic goals.

Programs must also be able to respond to uncertainty and risk. For example, an empty raceway today may be necessary to provide this type of flexibility in the future. The keys to flexibility are having sufficient supplies of land, water quality and quantity, and physical facilities; along with a planning mindset that takes the concepts of flexibility, managing change, and future needs into account.

Evaluate Hatchery Programs Regularly to Ensure Accountability for Success

Achieving successful hatchery programs (where benefits and risks are managed effectively) will require ongoing monitoring and evaluation (M&E), with some level of commonality and standardization across Puget Sound and coastal Washington. Each region of Puget Sound and the coast will need to develop its own M&E program consistent with the goals and programs of that region.

Monitoring should include not only expanded efforts to distinguish hatchery- and natural-origin fish, but also determining the fate of migrants in fresh and saltwater environments following

³⁰ See Appendix A, *Scientific Framework for the Artificial Propagation of Salmon and Steelhead*.



release. An integrated, region-wide hatchery M&E system needs to be developed that includes the systematic and annual evaluation of the co-mingling of hatchery and naturally-spawning fish.³¹

Furthermore, a modern, centralized M&E database where information can be evaluated annually for adherence to regional and system-wide goals needs to be institutionalized, in order to adaptively manage the system. Individual hatcheries need to be equipped with computers and Internet access that allow them to use and share data from a record collection system developed by the co-managers, such as the HatPro system.

³¹ See Appendix A, *Scientific Framework, Monitoring and Evaluation for Accountability and Success*.