Genetically Based Enhanced Contribution Guidelines for Pacific Salmon Populations

Salmonid Enhancement Program
Fisheries and Oceans Canada

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Objective

Canada's Department of Fisheries and Oceans Canada (DFO) is committed to minimizing undesirable genetic effects of hatchery enhancement of salmon populations, while balancing biological and socio-economic objectives. These guidelines provide an approach to evaluate genetic influence of enhancement transparently and consistently, focusing on conservation of wild salmon as a highest priority. These guidelines are designed to support hatchery program planning and decision processes. They function as a tool to support ongoing work to establish population-based implementation approaches in combination with other existing DFO frameworks and guidelines. As new formal scientific advice is acquired, these guidelines will be updated as needed. This approach is consistent with the guiding principles on conservation and open and transparent decision making in Canada's Policy for Conservation of Wild Pacific Salmon (hereafter referred to as the Wild Salmon Policy or WSP).

Scope

These guidelines were developed for hatcheries in British Columbia and Yukon (DFO's Pacific Region) that culture and release Pacific salmon for the objectives described in Appendix 2 of this document. They apply to DFO or DFO-partnered facilities managed or supported by DFO's Salmonid Enhancement Program (SEP). This approach does not pertain to Steelhead or Cutthroat trout cultured and released in the Pacific Region as their management is under provincial jurisdiction. These guidelines are founded on the scientific advice and principles within the 2018 Canadian Science Advisory Secretariat (CSAS) publication titled *Genetically Based Targets for Enhanced Contributions to Canadian Pacific Chinook Salmon Populations*. Although this CSAS advice was developed for Chinook salmon, it is considered highly appropriate for coho and sockeye salmon, and functional but conservative with respect to the risks stemming from the hatchery environment for pink and chum salmon. These guidelines do not provide specific decisions around managing genetic effects of enhancement but rather provide managers with a tool to quantitatively measure genetic influence and guidance to interpret those measurements in the context of the Wild Salmon Policy.

Overview

Canada's Wild Salmon Policy affirms that hatcheries may be used to rebuild populations with an unacceptable chance of extirpation, and to produce salmon for harvest opportunities and economic benefits. The WSP defines wild salmon as those that "*…have spent their entire life cycle in the wild and originate from parents that were also produced by natural spawning and continuously lived in the wild*" and emphasizes the need to maintain wild salmon spawning in natural habitats to conserve genetic diversity and fitness in current and future salmon populations. Furthermore, under the WSP, three types of salmon can be defined; 'wild salmon' originating in the natural environment from parents also born in the wild, 'enhanced salmon' originating from hatchery production and a third 'transition type' consisting of fish born in the natural environment from one or both parents of hatchery birth. The descriptor 'natural origin' is used to describe wild and transition fish combined, and distinguish them from fish of 'hatchery origin'. (Withler et al. 2018).

Where marking programs are in place, hatchery origin salmon can be identified. External marking in the form of adipose fin-clipping allows for immediate visual identification of a hatchery origin salmon. In most cases, internal marking methods such as otolith thermal marking, coded-wire tagging, and genetic parentage-based tagging allow for retrospective identification of hatchery origin salmon.

As part of science-based genetic management of hatchery production, the Canadian Science Advisory Secretariat (CSAS) provided scientific advice for DFO on genetically based targets for enhanced contributions to Canadian Pacific Chinook salmon populations in the context of the Wild Salmon Policy (DFO 2018a). The WSP utilizes Conservation Units (CUs) to define groups of Pacific salmon populations geographically and genetically, some of which may be subject to hatchery influences. A consistent formal method for assessing the degree of hatchery influence on individual enhanced populations within CUs will contribute to broader departmental assessments of CU status. CSAS (DFO 2018a) used the "proportionate natural influence" (PNI) index system to provide such a method. This system relates the level of hatchery influence in a population to the level of risk that hatchery salmon can pose to the natural adaptive and productive characteristics of the hatchery-influenced population. PNI is a widely applied metric developed by the U.S. Hatchery Scientific Review Group (HSRG) to evaluate, classify, and monitor levels of hatchery influence and genetic risk to the natural adaptive state of 'integrated' populations (HSRG 2009, HSRG 2015). Integrated populations in this context are those in which natural origin (including wild) and hatchery origin salmon spawn in both the hatchery and wild environments, with gene flow between the two. All populations enhanced by SEP are considered integrated populations.

These guidelines outline the application of the PNI metric and the associated biological designation system, as defined by CSAS (DFO 2018a), to support the management principles and objectives concerning the genetic influence of enhanced Pacific salmon. These guidelines also provide a description of the data and methodology that SEP uses to calculate the PNI for implementation of the CSAS advice, including methodologies under various data availability scenarios (Appendix 1). This approach will constitute the formal PNI estimates for SEP enhancement projects. Other parties may calculate PNI estimates for enhanced populations that vary from those generated by SEP due to differences in calculation methodology or data components. SEP PNI estimation results will be used in the planning, management, and assessment of SEP enhancement projects, as well as in communicating with respect to assessing and managing genetic influence of hatchery salmon on wild salmon. These guidelines also explain how the PNI metric can be reflected in the various enhancement production objectives when considering biological designations as part of production planning.

Previous SEP guidelines for the genetic management of enhanced Pacific salmon populations have been in place for many years and updated regularly (DFO 2016[1]). Under past guidelines, genetic risks could be managed by regulating the proportion of enhanced salmon that spawned within the naturally spawning population, the proportion of broodstock that is natural origin, and the proportion of the population removed for broodstock. This guidelines document provides more specific definition and direction on the appropriate proportion of enhanced salmon within spawning populations by incorporating recent advances in scientific understanding of salmon population structure and the effects of gene flow between wild and hatchery origin salmon (DFO 2018a).

These genetically based enhanced contribution guidelines are applied together with policy and biological frameworks within the formal SEP integrated production planning process (DFO 2018b). They also augment SEP's biological risk management framework for enhancing salmon (DFO 2013). The CSAS advice upon which these guidelines are based places genetic management of hatchery production on a sound scientific and policy footing, allowing DFO to implement the WSP transparently with respect to management of hatchery genetic influences.

[1] In the event of discrepancies between this and the existing guidelines, this document will take precedence while existing documents are updated.

Biological Designation

The PNI is an index of the degree of hatchery genetic influence in a population, calculated from the proportion of natural origin parents in the hatchery broodstock (pNOB) and the proportion of hatchery origin salmon on the spawning grounds (pHOS). PNI is measured on a scale from zero to one. The PNI value of a wild population with no hatchery influence can be considered one, while the value of a hatchery population with no natural influence can be considered zero (see Appendix 1). Biological designations for populations, as defined by CSAS (DFO 2018a), are attached to specific PNI ranges. There is a progression of biological designations from “wild” to “integrated hatchery”. Each designation denotes the associated proportion of WSP defined wild salmon, the environment that is imposing the dominant genetic influence (natural vs hatchery) and the PNI values that bound these biological status categories (Table 1). Note that the PNI is designed as an index of the potential risks to the fitness of wild populations resulting from interbreeding with hatchery origin spawners, but it is not a direct measure of changes in fitness, productivity or genetic diversity. Appendix 1 provides more information on PNI and specific calculation methodologies.

Table 1. Biological designations for salmon populations, with associated descriptions and metrics (DFO 2018a).

Biological Designation	PNI	WSP Wild Salmon* (%)	Description
Wild	n/a	≥ 92	Populations that do not have hatchery programs; straying from out-of-basin hatchery production is limited to <3% per year.
Wild-Stray Influenced	n/a	< 92	Populations that receive out-of-basin strays at rates that ≥3%. Majority of salmon are wild, but gene modelling suggests a long-term decline in PNI.
Integrated-Wild	≥ 0 .8	≥ 50	Enhanced populations in which wild salmon are the majority and gene flow is dominated by the natural environment.
Integrated-Transition	≥ 0 .5	≥ 13 to < 50	Enhanced populations in which natural origin salmon are the majority and gene flow is dominated by the natural environment.
Integrated-Hatchery	< 0.5	< 13	Enhanced populations in which hatchery origin salmon are the majority and gene flow is dominated by the hatchery environment.

*The WSP Wild Salmon column shows the expected proportions of natural origin to natural origin mating that would result in production of salmon qualifying as wild under the WSP, under the assumption of random mating.

Designations other than "Wild" in Table 1 apply to hatchery influenced populations and enable development of a target biological designation consistent with the established management goals for the population itself and the CU to which it may contribute. Surrounding wild populations that are not the direct object of enhancement will be classified as "wild" or "wild-stray influenced."

SEP has five specific production objectives for enhancement programs in the Pacific Region, which are described in Appendix 2. These objectives correspond to the outcomes of the national SEP performance management framework and form the basis for project performance evaluation. All SEP production release groups must address at least one of these program production objectives. Appendix 2 provides a more detailed description of the objectives and incorporation of biological designations and the PNI index.

Table 2: Application of Biological Designation by Enhancement Objective.

	Biological Designation		
Enhancement Objective	**Integrated-wild (PNI ≥ 0.80)**	**Integrated-transition (0.50 ≥ PNI< 0.80)**	**Integrated-hatchery (PNI <0.50)**
Harvest	**Appropriate.** Harvest objectives and hatchery influence are set to maintain wild status. Risk tolerance for loss of wild adaptive traits is low.	**Conditional: assessment of trade-offs required.** Harvest objectives and hatchery influence are set to maintain dominant natural genetic influence. Natural origin salmon predominate. Risk tolerance for loss of wild adaptive traits is moderate.	**Conditional: assessment of trade-offs required.** Harvest objectives and hatchery influence are set with acceptance of high levels of hatchery genetic influence. Hatchery origin salmon predominate. Risk tolerance for loss of wild adaptive traits is high.
Assessment	**Appropriate:** Assessment objectives and hatchery influence are set to maintain wild status. Risk tolerance for loss of wild adaptive traits is low.	**Conditional: assessment of trade-offs required.** Assessment objectives and hatchery influence are set to maintain dominant natural genetic influence. Natural origin salmon predominate. Risk tolerance for loss of wild adaptive traits is moderate.	**Conditional: assessment of trade-offs required.** Assessment objectives and hatchery influence are set with acceptance of high levels of hatchery genetic influence. Hatchery origin salmon predominate. Risk tolerance for loss of wild adaptive traits is high.
Conservation	**Appropriate:** Conservation objectives and hatchery influence are set to maintain wild status. Risk tolerance for loss of wild adaptive traits is low.	**Conditional: assessment of trade-offs required.** Hatchery production is aligned as part of an enhancement plan linked to stock recovery actions. As early conservation benchmarks are achieved, hatchery production should be adapted, and steps taken to manage the population to a higher biological population designation category. Risk tolerance for loss of wild adaptive traits is moderate.	**Conditional: assessment of trade-offs required.** Risk of loss of wild adaptive traits may be temporarily traded off with the risk of losing genetic resources/population through extirpation. Elevated levels of hatchery contribution may be necessary in these initial stages; however, as early conservation benchmarks are achieved, hatchery production should be adapted, and steps taken to manage the population to a higher biological population designation category. Risk tolerance for loss of wild adaptive traits is moderate to high.
Rebuilding	**Appropriate:** Rebuilding objectives are set to increase abundance and temporal/spatial diversity (spawning and rearing), while maintaining wild status. Risk tolerance for loss of wild adaptive traits is low.	**Conditional: assessment of trade-offs required.** Hatchery production should be aligned as part of an enhancement plan linked to stock recovery actions. As early rebuilding benchmarks are achieved, hatchery production should be adapted, and steps taken to manage the population to a higher biological population designation category. Risk tolerance for loss of wild adaptive traits is moderate.	**Not appropriate:** Effective population size is sufficiently large to buffer against loss of genetic diversity. Immediate steps should be taken to manage the population to a higher biological population designation category. Risk tolerance for loss of wild adaptive traits is low.
Stewardship/ Education	**Appropriate.** Risk tolerance for loss of wild adaptive traits on the target population is low.	**Not appropriate**: Immediate steps should be taken to manage the population to a higher biological population designation category. Risk tolerance for loss of wild adaptive traits is low.	**Not appropriate**: Immediate steps should be taken to manage the population to a higher biological population designation category. Risk tolerance for loss of wild adaptive traits is low.

Determining target biological designation as a component of enhancement objectives supports project planning and appropriate scaling of production levels. A range of designations may be considered within objectives to reflect population specific circumstances (Table 2). Some of these specific circumstances may include:

- the level of hatchery production required to support a planned harvest as established through an approved planning process, precludes maintaining an integrated-wild population.
- hatchery production is present but previously available habitat is no longer present to maintain a self-sustaining wild population due to severe negative disturbances (e.g. the Capilano River where the installation of a dam has limited salmon access to much of the spawning habitat). This situation may in many cases be long-term, depending on the feasibility and likelihood of habitat restoration, but would not normally apply in cases where enhancement is exceeding natural unaltered spawning capacity. Where habitat restoration is feasible and likely, target PNI values will be established as part of an enhancement plan in support of a restoration implementation plan.
- a population has a conservation enhancement objective (highly at risk of extirpation or extinction) and the short-term risks of elevated levels of enhanced contribution are deemed to be less than the risk of extirpation or genetic bottlenecking in the absence of enhancement. This situation would be considered temporary, with a return to a higher biological designation when feasible, and with target PNI values established as part of a conservation or recovery plan. A sliding scale of PNI targets may be established, with a lower PNI accepted initially to avoid extirpation and a subsequently higher PNI target as abundance increases. This situation, with an initially high, but gradually diminishing level of enhanced contribution would also apply where there is an approved transplant that is intended to re-establish or rebuild a stock until it is self-sustaining.
- a population has an assessment enhancement objective and stock assessment requirements may carry production commitments that preclude maintenance of an “integrated-wild” population. The value of the data for management and sustainability of wild salmon is deemed greater than the genetic risk to the population.
- an approved transplant which has not become self-sustaining and requires on-going enhancement to meet enhancement objectives has resulted in a population that has few WSP defined wild salmon (e.g. Chilliwack fall Chinook).

Once established, these designations can be included in the SEP hatchery production planning process for each population and together with the enhancement objectives (harvest, assessment, rebuilding, conservation, or stewardship) form part of the enhancement plan for each production group.

In most instances where the current hatchery influence is too high to align with the established biological designation goals, decisions can be made to employ some combination of the following actions to reduce the level of hatchery influence:

- reduce hatchery production levels, the most effective management measure;
- increase the proportion of natural origin salmon used in broodstock; or
- remove or exclude hatchery origin salmon from spawning grounds either through a fishery or direct removal from spawning grounds.

The latter two actions are predominantly dependent upon some type and level of visual marking that allows differentiation of hatchery origin from natural origin salmon prior to spawning.

Implementation Process

SEP has developed a standardized methodology for consistent and repeatable calculation of PNI under various data availability scenarios and determined the current enhanced influence on Chinook populations across different projects where data is available, with other species/projects to follow.

Evaluation of the level of hatchery influence (via PNI) and determination of biological designation goals are linked but separate processes. Hatchery programs operate at the population level and biological designation goals will be applied to populations on a case-by-case basis. However, planning can be influenced by a population's context within its CU since the WSP assessment and management takes place at the CU scale and CUs are the unit of salmon biodiversity DFO manages towards. Any standardized approach to assessment of CU status would consider the role that enhanced populations play in the biodiversity of the CU, which would inform perceived risks and the biological designation process. For example, the enhancement risk to a CU with only one population would be greater than that to a CU with 10 populations of which one is enhanced, and the rest are unenhanced, assuming the occurrence of hatchery strays in unenhanced systems are <3%.

The full process for establishing population biological designation goals requires development, as the WSP implementation and integrated stock management planning processes continue. Priority populations for evaluation will include populations within WSP Red listed CUs or that fall under a WSP-type benchmark themselves, or that are part of other status assessments such as the *Fisheries Act*.

References

DFO. 2005. *Canada's Policy for Conservation of Wild Salmon.* Fisheries and Oceans Canada, Vancouver, B.C. ISBN 0-662-40538-2.

DFO. 2013. *A Biological Risk Management Framework for Enhancing Salmon in the Pacific Region*. Salmonid Enhancement Program, Fisheries and Oceans Canada, Pacific Region.

DFO. 2016. *A Compilation of Operational and Planning Guidelines for the Salmonid Enhancement Program.* Salmonid Enhancement Program, Fisheries and Oceans Canada, Pacific Region.

DFO. 2018a. *Review of genetically based targets for enhanced contributions to Canadian pacific Chinook Salmon populations.* DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/001.

DFO. 2018b. *SEP Production Planning: A Framework 2018*. Salmonid Enhancement Program, Fisheries and Oceans Canada, Pacific Region.

DFO. 2018c. *SEP Biological Assessment Framework*. Salmonid Enhancement Program, Fisheries and Oceans Canada, Pacific Region.

Hatchery Scientific Review Group. 2009. *Report to Congress on Columbia River Basin Hatchery Reform*.

Hatchery Scientific Review Group. 2015. *Annual Report to Congress on the Science of Hatcheries, 2015*. A report on the application of up-to-date science in the management of salmon and steelhead hatcheries in the Pacific Northwest.

Appendix 1 - Estimating Hatchery Genetic Influence on Wild Populations

The proportionate natural influence (PNI) metric is an index of the relative degree of natural genetic influence in a population. PNI is intended as an index of risk to guide hatchery management. For integrated hatchery populations such as those managed by the SEP, PNI is computed as:

$$PNI = \frac{pNOB}{(pNOB + pHOS)}$$

where

- pNOB is the proportion of natural origin parents in the hatchery broodstock, and
- pHOS is the proportion of hatchery origin spawners in the natural habitat.

PNI values range from zero to one, with higher values for populations more strongly influenced by the natural environment. A PNI value greater than 0.5 indicates gene flow favouring the adaptive influence of the natural environment, while a PNI value of less than 0.5 indicates gene flow where the adaptive influence of the hatchery environment is dominant (Figure A -1).

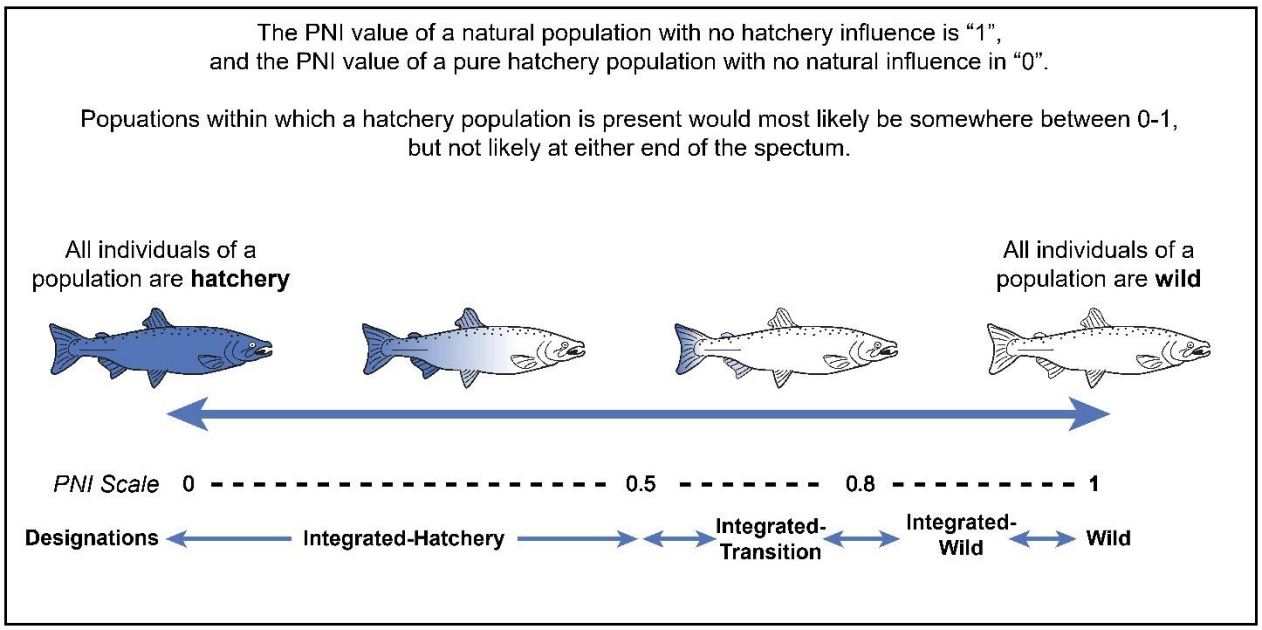


Figure 1. Proportionate natural influence (PNI) as a measure of hatchery genetic influence.

Estimating PNI requires the ability to identify hatchery origin and natural origin salmon with certainty by means of the presence of one or multiple mark types applied in the hatchery environment. The data available for estimating the PNI varies amongst SEP projects and production groups depending on the level of marking and subsequent sampling and enumeration of hatchery and natural spawning populations. Some projects have direct assessment of all data components while others include assessment of only some, or even none, of these elements. Where multiple data sets are available, the best available at the time will be applied. The Biological Assessment Framework (DFO 2018c) describes SEP assessment methods including marking and sampling for direct assessment and the use of biostandards (average values from representative populations that can be applied to other populations) for indirect

assessment. Alternative credible data will be analyzed, and the most defensible data utilized for PNI assessment. PNI will be assessed on an annual basis and managed through rolling averages over multiple years to assess levels and trends in hatchery influence. In most cases, SEP uses a rolling average equivalent to the dominant age class of the population being assessed.

SEP utilizes data from DFO internal databases (primarily the SEP *Enhancement Planning and Assessment Database* - EPAD), which is in turn populated with data from SEP enhancement facilities, and information from DFO Stock Assessment.

Depending on project specifics and data available, SEP PNI estimate types will be as follows. Figure 1A-1D provides flowcharts of calculations.

1) **Direct** – Direct estimates of both pHOS and pNOB are available. Population is marked (Coded Wire Tags (CWT), adipose clips, otolith, or Parentage Based Tags (PBT)) and both river and broodstock are sampled independently. Standard statistical assumptions and methodologies apply with respect to the marking and sampling methods (DFO 2017).

2) **Partial Direct** – The enhanced population is marked but there is a direct estimate of only one of pNOB or pHOS. In this case, where pHOS is unknown, it is estimated using the mark encounter rate during broodstock collection in circumstances where broodstock is collected in a manner that represents the natural run spatial and temporal distribution. Inversely, in rarer cases where pNOB is unknown, it is estimated using the mark rate encountered in the natural spawning environment. Some partial direct PNI estimates may have higher confidence than others, based on project specifics. For example, if the broodstock count is very small or collected in a non-stratified manner, it may not represent the spawning population accurately.

3) **Indirect** – The enhanced population is not marked but appropriate survival rate, exploitation rate and age composition biostandards (average values from representative enhanced populations that can be applied to other populations) are available. No direct estimate of pHOS or pNOB is available and the PNI is calculated from SEP's biostandards. It is possible to estimate a pHOS greater than 1 when using the indirect method due to variability in exploitation, marine survival, and natural productivity.

4) **No Estimate** – No estimate of survival or production is possible (e.g. population is not marked, neither broodstock nor natural spawning populations are sampled and there is no appropriate biostandard indicator). In this instance the PNI cannot be calculated, and the program must be scaled to an appropriately low risk level of production.

Notes on SEP Calculations

The data available for estimating the PNI varies amongst SEP enhancement projects depending on the level of marking, sampling, and enumeration of hatchery and natural populations. Some projects have assessment of all required data components for estimation of PNI, while others include assessment of only some, or even none, of these components. Standard statistical methods are used for CWT calculations (expansion, lost pin, no pin etc.) (DFO 2017).

SEP's PNI analyses are operational evaluations undertaken to support key SEP operational constituents, such as production planning processes and status of program objectives. Analyses performed by others to support specific research may generate different results. The methods and assumptions that follow represent SEP's current approach to PNI analysis. The results are the product of an evolving and accumulating knowledge base, which in turn may give rise to revised methodologies over time. These guidelines will be updated to reflect such changes as required.

PNI calculation methodologies and assumptions

- The census pHOS ($pHOS_{census}$) is the observed pHOS whereas the effective pHOS ($pHOS_{eff}$) is a discounted value accounting for the reduced reproductive success of hatchery origin salmon in the natural environment. SEP uses $pHOS_{census}$ for PNI calculation as opposed to $pHOS_{eff}$. This provides a more conservative PNI estimate, thus targeting a higher proportion of wild salmon at various biological designations.
- River returns from multiple strata (e.g. sexes, ages, sample locations in escapement) are aggregated for PNI analysis and include jacks. They are not stratified by age or sex for SEP analyses.
- EPAD reports for CWT-based estimates of contribution of enhanced salmon to broodstock use the final expanded[2] estimate of enhanced salmon divided by the total broodstock count. See DFO (2017) for a description of expansion methodology.
- There are scenarios in which visually unmarked salmon are preferentially selected for broodstock. In these cases, the encounter mark rate of brood capture will differ from the mark rate of salmon used for broodstock. Estimates of pNOB will use the mark rate of salmon used for broodstock where the encounter rate of brood capture is used to estimate pHOS where required and appropriate.
- There are scenarios when only a portion of hatchery production is visually marked. In these cases, the expanded encounter rate can be used to estimate the enhanced contribution to the broodstock capture sample. This expanded estimate, minus the marked salmon not included in the broodstock removals, provides the estimated number of unmarked hatchery origin salmon in the broodstock.
- In many cases (i.e., where salmon are not preferentially removed from broodstock), the mark rate for total removals, and the mark rate of salmon used for broodstock, is the same.
- In situations requiring partial direct PNI estimates, the sampled strata (pHOS or pNOB) can only be used if it is collected in a manner that is representative of the spatial and temporal distribution of the unsampled strata.
- If no broodstock is collected so that pNOB = 0, then PNI will not be reported. If there is no broodstock but there are hatchery salmon in the river, pHOS could be reported if data were available.

[2] Expanded enhanced contribution accounts for both marked and unmarked enhanced salmon

- Not all years with PNI estimates are complete cohorts due to some contributing broodstock years not being marked. PNI estimates without complete marked cohorts will have PNI estimates that are biased high. The mark rate for the missing years may be extrapolated from adjacent marked years/cohorts or from biostandards.

Populations that carry Coded Wire Tags (CWT)

- pNOB is calculated based on the estimated number of enhanced salmon in the broodstock, divided by the total count of the broodstock.
- Similarly, pHOS is calculated based on the estimate of enhanced hatchery origin spawners in the natural spawning population divided by the total count of spawners in the natural spawning population.

Populations that carry thermal marks

- Where thermal marks are available, the proportion of salmon that are hatchery origin is calculated based on the thermal mark rate.

Populations that carry multiple marks

- If data from multiple marks are available (thermal marks, CWTs, PBTs), the best quality data set for each stratum will be utilized for PNI calculations (based, for example, on sample size, sample representativeness and mark quality). In cases where escapement samples were stratified by adipose fin clip status (e.g. marked salmon were sampled for CWT and unmarked were sampled for otoliths resulting in two mark rates) a combined sample with an overall mark rate may be more accurate.

Hatchery Straying

- Stray hatchery salmon are defined as those that spawn in a system other than their system of origin. Hatchery strays are only detected in sampled systems where hatchery salmon are marked; not all systems adjacent to hatchery streams are sampled for hatchery spawners.
- Withler et al. (2018 and references within) discuss the genetic impacts of hatchery straying in natural salmon populations. It is recognized that hatchery straying into natural populations can produce a loss of fitness in subsequent generations. This is true for both unenhanced and enhanced populations. Strayed hatchery origin spawners likely have a greater negative effect on fitness than do local hatchery origin spawners. SEP's PNI calculation methodology does not currently consider the potential greater impact of strays on PNI. It is recognized that this approach may overestimate PNI for populations that experience substantial straying from hatcheries.
- Accurate estimation of PNI for populations that experience both local enhancement and out-of-system strays requires assumptions of unknown parameters such as heritability and the strength of selection. Currently, methods to estimate PNI that account for the effects of both local and strayed hatchery salmon do not exist. As a result, SEP calculates PNI as above, and monitors hatchery straying via another metric, $pHOS_{stray}$ (the proportion of hatchery origin spawners originating from a different system of origin).
- Withler et al. (2018) established a 3% threshold for the contribution of strays to an unenhanced population, beyond which a long-term genetic risk was indicated for the recipient population.
- Further work is required in developing methods to characterize the impact of hatchery strays on PNI calculations and the associated genetic risk for both enhanced and unenhanced populations.

Figure 1A. PNI Calculation Methodology – Determine PNI Estimate Type

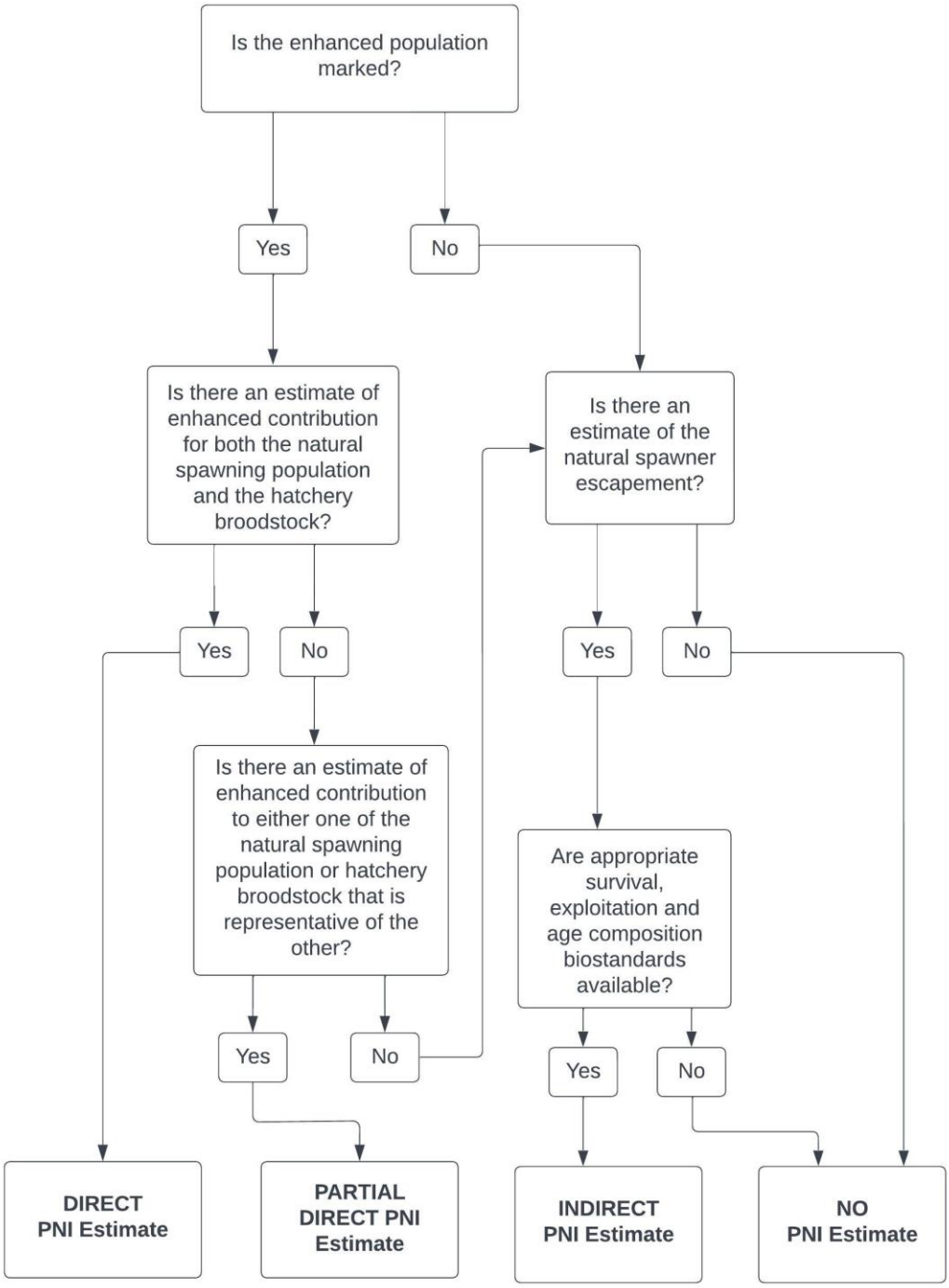


Figure 1B. PNI Calculation Methodology – Direct PNI Estimate

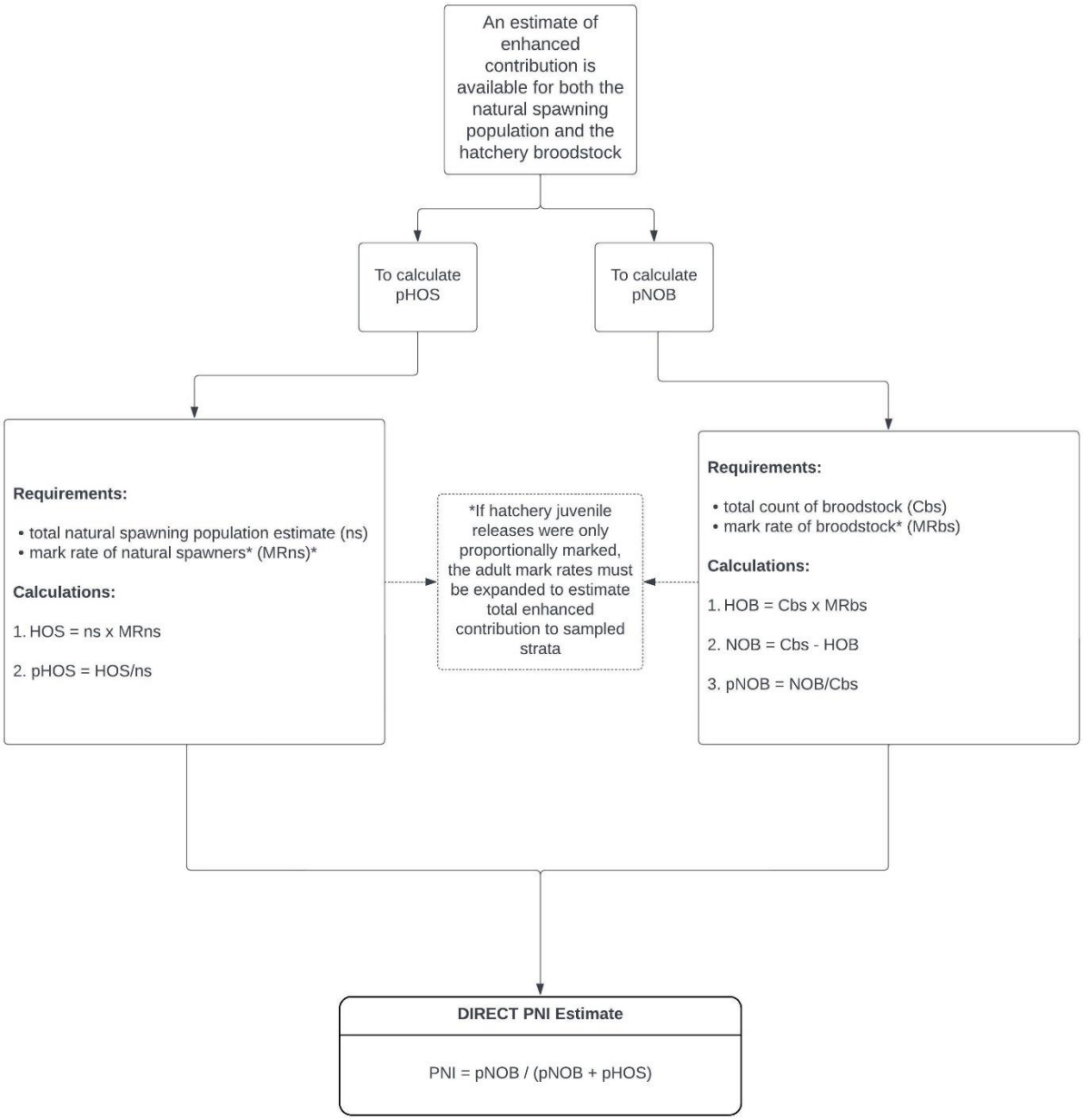


Figure 1C. PNI Calculation Methodology – Partial Direct PNI Estimate

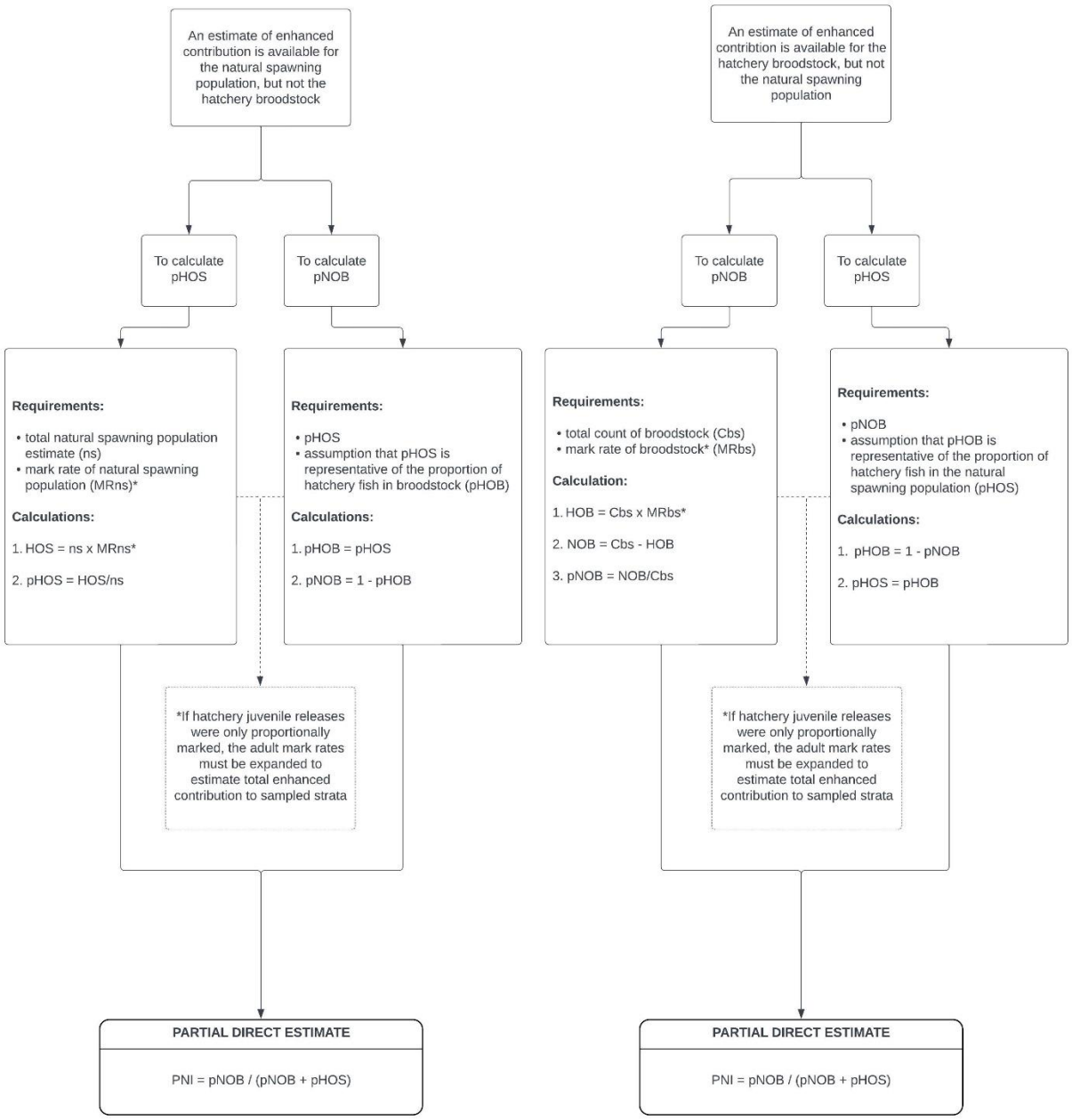
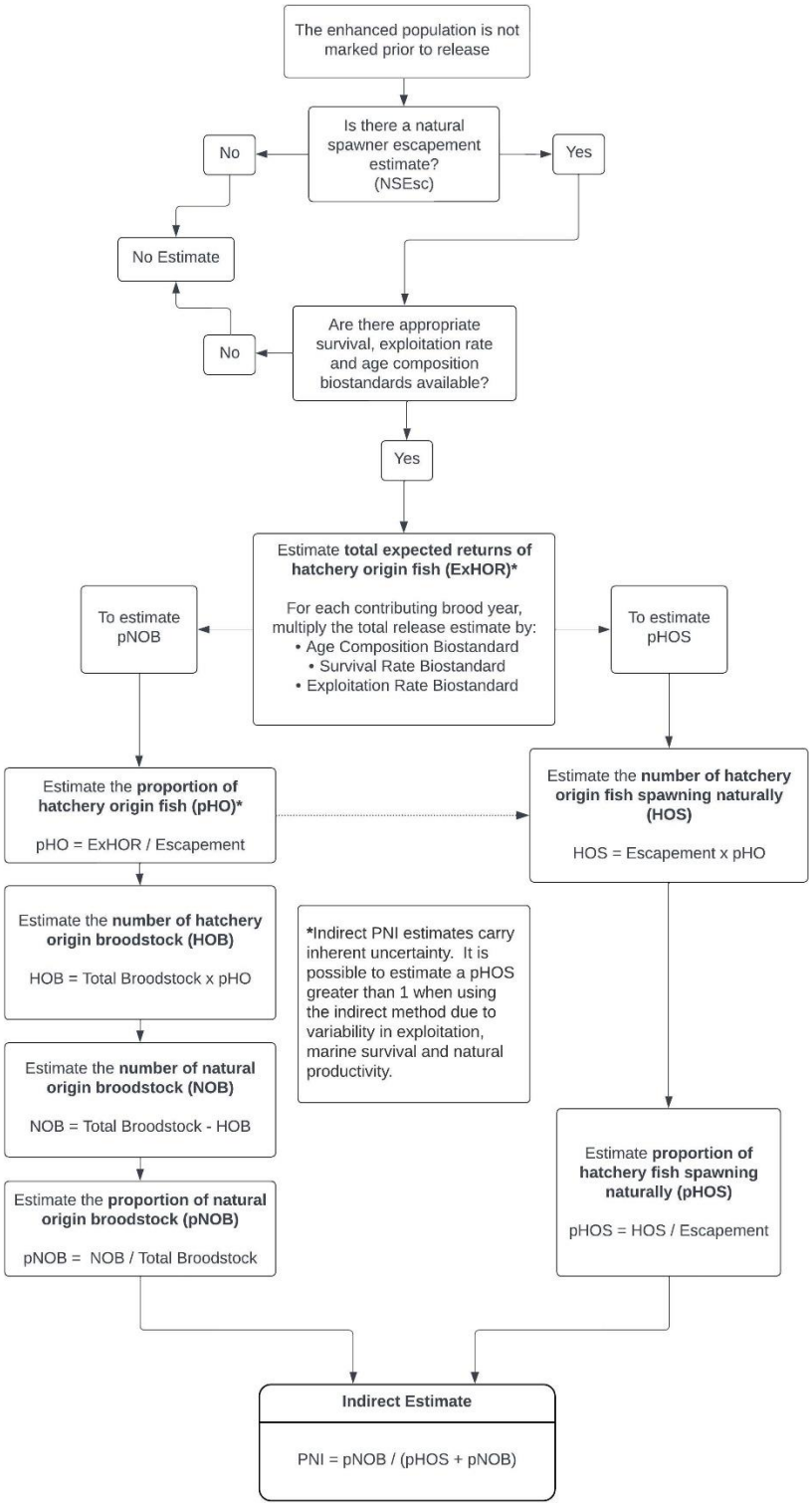


Figure 1D. PNI Calculation Methodology – Indirect PNI Estimate



Appendix 2 - Expanded Guidance on Enhancement Objectives and Biological Designation

This appendix presents additional detail on the definition of enhancement objectives that incorporate the "salmon biological designation" system to acknowledge and manage the genetic risk that hatchery salmon can pose to wild salmon populations. The designations are based on the use of the proportionate natural influence (PNI) metric as described in Appendix 1. Consideration of biological designation as a component of enhancement objectives supports project planning and appropriate scaling of production levels, particularly when a range of designations may be considered within objectives to reflect stock specific circumstances (Table 2). Accurate identification of the enhancement objective is critical as policy and regulatory components, such as salmon health management requirements, may be linked to objectives, as may resource priorities.

SEP Enhancement objectives are:

Conservation:

Conservation programs are specific to the enhancement of a population at risk of extirpation or extinction, ideally identified as part of Committee on the Status of Endangered Wildlife in Canada (COSEWIC), WSP, or other formal Conservation Unit status assessment. However, populations with continuous declining trends in escapement that meet at-risk status assessment criteria may be considered for conservation enhancement, particularly where there are highly unique genetic characteristics (e.g. single census CUs).

The goal of such enhancement is to prevent extinction/extirpation and secure genetic resources. Where the causes of decline are unidentified, the initial goal may be to preserve the unique genetics of the population while limiting factors are identified, assessed, and addressed. Once the population has stabilized to a pre-determined level of spawner abundance, as identified in an enhancement plan, the production objective in most cases will transition to a rebuilding objective, with the goal of increasing the average abundance of spawning adults to a specified target while also monitoring and managing the enhancement to maintain natural genetic influence by decreasing the proportion of hatchery salmon over time.

Conservation and rebuilding programs ideally respond to an identified need for enhancement as a component of management actions for a population (i.e. status assessment, drivers of status, plans to address drivers). They should be part of a comprehensive strategy for the population overall that includes an enhancement plan with defined escapement targets, benchmarks and timelines, and where hatchery, habitat, and harvest measures are coordinated to meet clearly articulated population management plans. Goals and recovery objectives must reflect current habitat and productive capacity and acknowledge that conditions may no longer support past production levels. A conservation program involves high intensity enhancement and must be characterized by clear objectives, a clear plan to transition through recovery phases, a robust monitoring program, and strong safeguards.

With respect to biological designations, long-term PNI targets may not be met during the early recovery phase when the primary focus is to increase abundance in both the hatchery and natural environments (i.e. a higher hatchery influence and low PNI) could be temporarily accepted as the population recovers.

Rebuilding

Rebuilding programs are designed to restore a depleted population that is below optimal escapement to a state of greater abundance and natural viability. That state will depend on the future productivity of all habitats and may not be the same as former levels of abundance. As with conservation enhancement, rebuilding programs should be combined with a integrated recovery plan that identifies and relieves population stressors, with realistic population and CU goals. An enhancement plan with defined biologically-based triggers (e.g., escapement targets, benchmarks, and timelines) should be developed. As a population shows signs of recovery, hatchery production is meant to be reduced in a stepwise, pre-planned manner that meets the benchmarks of the enhancement plan and is meant to be discontinued when the population is considered at a stable "rebuilt" status. Rebuilding programs may be utilized to temporarily support populations through catastrophic circumstances, but they are not intended to be lasting measures, nor are they meant to be long-term safeguards against sporadic and unpredictable climatic events that may affect spawning success.

If the population does not respond to enhancement rebuilding measures within the planned timelines, the project should be re-examined and enhancement as a tool overall within the recovery plan may be re-considered. For example, other measures, such as creation of off-channel habitat to mitigate against flood events may be more suitable. Rebuilding targets should be set for current habitat and productive capacity and recognize that past production levels may no longer be feasible.

As the purpose of a rebuilding program is to restore a wild population, risk tolerance for loss of wild adaptive traits as per the biological designation, is low. Integrated-wild is the appropriate long-term designation but integrated-transition is conditionally acceptable as the population recovers. An enhancement plan should articulate these phases of recovery.

Assessment

Assessment programs include salmon production for the specific purpose of addressing DFO assessment objectives, including supporting the Pacific Salmon Treaty (PST) and regional stock assessment requirements. Production levels for assessment must be coordinated and integrated with regional stock assessment frameworks and any other relevant arrangements, such as the PST, and will be marked and sampled in fisheries and/or the escapement according to requirements and protocols jointly established with Science Branch. This objective does not include assessment undertaken to evaluate performance of any specific production line as such assessment is integral to the project but not a component of regional assessment.

When considering biological designation, risk tolerance for loss of wild adaptive traits on the target population is low to medium but greater risk may be tolerated where the value of assessment information is considered to outweigh risk. For example, the enhanced production may provide the only source of data to assess and inform management and protection of wild salmon CUs of conservation concern.

Harvest

Harvest programs include enhancement for targeted fisheries that are reliant on enhanced production and that become significantly constrained in the absence of enhancement. Such fisheries may be commercial scale or small but consistent localized fisheries. Enhancement plans should identify the intended fishery, the expected contribution to the fishery, and a program performance monitoring plan. Harvest access must be licenced and compliant with DFO allocation policy and any other current applicable policies and regulations.

A range of biological designations may be acceptable, depending on harvest benefits and the risk tolerance for loss of wild adaptive traits.

Stewardship and Education

Enhancement for stewardship and education purposes involves limited numbers of salmon produced or utilized to raise awareness and provide the public with opportunities to participate and learn about salmon and ecosystems. Risk tolerance for loss of wild adaptive traits on the target population is low.

Dual Objectives

Dual production objectives may be identified for a single production line. Typically, the combinations will be "assessment" (addressing DFO assessment objectives as defined above) combined with one of the other objectives (e.g. assessment/harvest). Such a combination is appropriate where there is a specific component of the production line that is marked for assessment, with the balance supporting the other objective (i.e. harvest). If the assessment were to be discontinued, the remaining production would continue with only the harvest objective. A dual objective involving assessment is not appropriate when the assessment is that which would be done routinely to assess the performance of the production line (e.g. assessment/rebuilding, where the assessment refers to evaluating the progress towards rebuilding goals). Such assessment should be undertaken as a matter of course but would not be identified as an objective of production. In this case, the objective would be only "rebuilding." Where assessment is the primary reason for the program and production is set accordingly, rebuilding may occur as an ancillary benefit of the production for assessment. However, as the rebuilding was not the specific objective, a dual objective is not warranted, and the objective would be only "assessment."