Operational Guidelines for Pacific Salmon Hatcheries

Production Planning, Broodstock Collection and Spawning

Scope of Guidelines

These guidelines have been developed to guide production planning, broodstock collection and spawning of Pacific salmon at hatcheries and incubation facilities. They provide strategies to manage production planning and genetic resources in order to preserve as much as possible the entire range of genetic material within an existing population. The guidelines do not apply to steelhead or cutthroat as the management of these species is a provincial responsibility.

Production Planning

Enhancement undertaken to meet local production objectives for populations should be planned and implemented within an integrated planning process and involve establishing juvenile release targets and strategies that will produce the number of adults desired while considering species interactions, effects on existing stocks, harvest, habitat capacity and project capacity. Enhancement objectives fall generally into two main categories, recovering and rebuilding populations and providing harvest opportunities, as follows:

- **Recovering and rebuilding populations**- including re-establishing locally extinct populations, rebuilding populations at high risk of local extinction, rebuilding depleted populations, and mitigating for habitat loss. Production targets will be set at levels that re-establish the naturally spawning population but that limit the risk of changing its genetic variation by regulating the proportion of enhanced fish that spawn within the naturally spawning population. Release targets and strategies should be set such that returns salmon of enhanced origin do not exceed 50% of the escapement goal. This may be exceeded in years prior to full achievement of target.

  Where the objective is re-establishment of a locally extinct population or where the population is the focus of an active recovery process, such as under the Species at Risk Act (SARA), broodstock collection plans and enhanced contribution should be set as part of the recovery or production planning process and may exceed these limits in order to address the recovery objectives and schedules

- **Provision of targeted harvest opportunities** including harvest opportunities for First Nations, recreational, or commercial fisheries; a list of facilities currently addressing this objective will be provided at a later date. When the objective of production is to provide a targeted fishery opportunity, production targets may be set to address both natural production and harvest requirements. The proportion of the naturally spawning escapement that may be comprised of hatchery fish should be established as part of an integrated planning process that links fish production with harvest planning for the target fishery and considers hatchery and natural escapement requirements. If the proportion of the escapement to be comprised of enhanced fish

or collected for broodstock is not established through a production planning process, the limits that are set for rebuilding and recovery will apply.

Genetic Management – Broodstock Collection and Spawning Practices

Sufficient broodstock that adequately represent the entire donor population and its genetic characteristics are essential to minimize the potential for loss of variation and undesirable genetic effects. Appropriate broodstock selection and spawning practices can minimize chance genetic events and maintain genetic variability of the population. Such practices are critical for determining the genetic make-up of a population and its long-term fitness.

Broodstock Collection

For all program objectives

The collected broodstock should as far as possible be randomly selected to represent the entire range of run timings, age groups, body sizes, etc. Key aspects are:

- maximize the effective breeding population.
- use fish from the entire run timing.
- collect broodstock randomly from the whole population to represent fish from the full range of physical characteristics, including small, or sexually precocious fish.
    - collect jacks proportionally to their abundance in the escapement as these precocious males may contain genetic material important for the long-term fitness of the population.
    - avoid artificial or intentional selection of spawners in order to preserve and maintain genetic diversity, and minimize artificial selection.

- Where egg targets are small ($\leq$ 10,000 eggs) or when weather or logistical circumstances confine broodstock collection to a short period (e.g. one weekend), strategies to improve representativeness should be employed. These could include collecting some broodstock from as many sites as possible within the river and/or collecting broodstock from a different portion of the run timing each year.

Where the objective is rebuilding or recovering a population

a) **For depleted populations that are not part of active recovery planning processes,**

- Do not remove more than one third of the naturally spawning escapement for hatchery use. This may mean that production targets will not be achieved. Allow the remaining fish to spawn naturally to maintain a viable naturally spawning population.

- When collecting brood from a fence or hatchery collection rack, collect about one third of the fish handled on each occasion, stratifying by sex.
- When collecting broodstock without a fence or hatchery fishway (angling, seining etc.), estimating one third of the total return may be difficult. If it appears that returns are weak, broodstock collection should be conservative. Consult knowledgeable staff and consider the previous cycle year escapement.
- Where returns are weak, broodstock utilized will frequently be limited and involve small numbers of adults. Careful adherence to spawning guidelines is critical to mimimize risks of genetic change

- Where there are approximately equal proportions of wild and externally identifiable hatchery fish in the return, it is acceptable to include both groups in the broodstock at their rate of occurrence, recognizing that not all hatchery fish may have been marked at release.
- Where externally identifiable hatchery fish predominate in the portion of the escapement accessible for broodstock collection, the proportion of hatchery fish utilized should be roughly the inverse of their proportion in the sample to ensure adequate representation of wild fish. (e.g. 70% hatchery, 30% wild in the sample – broodstock should be comprised of about 30% hatchery fish and 70% wild).
- Where hatchery fish are not externally identifiable, use broodstock collection methods that include all run timings and body sizes to provide a mix of hatchery and wild returns that represent the population.

b) **For populations in active recovery processes**:

Broodstock collection plans and options should be developed in advance as part of a recovery planning process and must be reviewed and endorsed by the recovery team. General considerations are:

- As far as possible, avoid the use of identifiable hatchery fish in broodstock. However, where returns are severely depleted, inclusion of some hatchery origin fish may be necessary.
- Broodstock removals may comprise up to 50% of the returning spawners particularly if habitat is very poor, resulting in poor wild production. As populations decline, from a genetic perspective, it may be preferable to use all available spawners as broodstock. However, this strategy carries the risk of catastrophic loss of the entire population if a problem is encountered in the hatchery.

Where the program objective is sustaining a targeted fishery.

- The proportion of the escapement removed for broodstock should be developed as part of the production planning process for the target fishery. In the absence of a planning process, the proportion removed should be the same as that used for the recovery objective i.e. no more than one third of the naturally spawning escapement.
- When the enhancement objective is a targeted fishery, broodstock are frequently collected entirely at the hatchery rack and are comprised of fish that that swim into the hatchery. Infusion of wild salmon into the hatchery broodstock (about 10%) can be beneficial. However, it is acceptable to obtain all broodstock required from fish that swim into the hatchery when broodstock populations are in excess of 100 pairs as a small proportion of the return is likely to have originated from naturally spawning fish.
- Infusion of wild broodstock from capture outside of the hatchery is not likely to have an appreciable effect when broodstock populations are in excess of 100 pairs but will be beneficial when broodstock populations are smaller.

Spawning

All Objectives – all broodstock population sizes

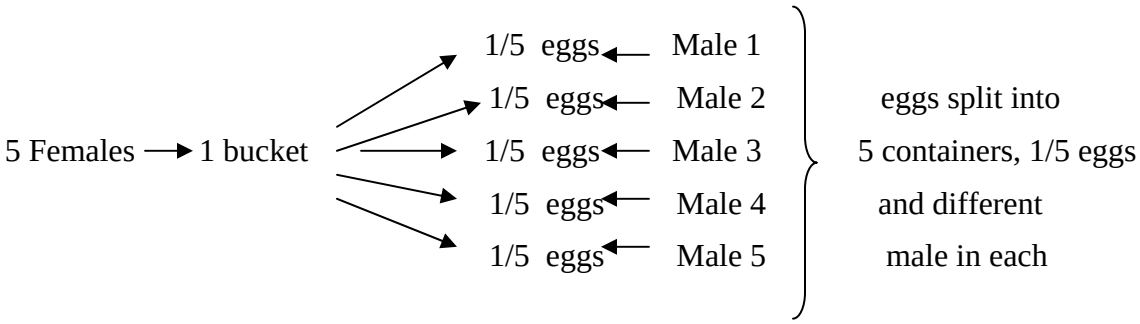
- Spawn all collected fully mature broodstock, without regard to age, size or other physical characteristics. Do not exclude any individuals for any reason except for those with overt disease symptoms or physical injuries that may compromise gamete fertility or viability.
- Use fully random mating; avoid any selection. Natural mating patterns are complex and poorly understood, and unlikely to be maintained in a hatchery environment.
- Use one male to one female except as described below. This strategy ensures that each male makes an equal genetic contribution.
- Do not mix the milt from two or more males and then add it to eggs. This practice is known as "pooling" milt and can result in milt from a single male fertilizing a disproportionate share of the eggs.
- It is strongly advised that males not be re-used, except as part of specific spawning protocols. In a sequential protocol two males may be used sequentially per female. A given male should be used as the first male for only one female, as follows:

- Consult a support biologist if you are planning to re-use males in any way other than the spawning protocols identified in these guidelines.
- Generally, do not release live males that have been used for hatchery spawning back to their systems of origin. These males will already have contributed a disproportionate amount of genetic material to the stock compared to wild fish, and, if released, would have the opportunity to contribute even more. Consult a support biologist, however, if there is a very disproportionate sex ration among natural spawners.

Spawning Broodstock of More Than 50 Pairs

- When spawning more than 50 broodstock pairs with:
    - a sex ratio of approximately 1:1, mate each female with an individual male. This helps to maintain genetic diversity.
    - more females than males, use matrix spawning (Table 1) or the following **hierarchical** spawning strategy , where milt from individual males is split amongst available females. Milt must not be pooled.

- One to one spawning is most desirable. However, in spawning situations where it is logistically difficult to keep eggs from individual females separated prior to fertilization (e.g. greater than 250 independent crosses or remote field situations), factorial mating may be considered. Eggs from a number of females are pooled, then gently and thoroughly mixed. Pooled eggs are divided into equal lots in separate containers with the number of containers equal to the number of constituent females. Each lot is then fertilized with milt from a different male, as follows. Milt must not be pooled.



Spawning Broodstock of Fewer than 50 Pairs

- When spawning fewer than 50 pairs, regardless of sex ratio, attempt to utilize all adults in **matrix** type breeding to maximize genetic variation in eggs. (Table 1). In matrix spawning, eggs from each female are divided into equal lots. Each lot of an individual female must be fertilized by a different male. This strategy allows the use of all broodstock, even when the sex ratio is unequal, and maximizes genetic combinations and each parent's contribution. It also allows information on families to be tracked if required.
- The matrix choice will depend on broodstock maturity, availability, and sex ratio. A minimum of two of the least available sex is recommended for each matrix and for practical purposes, a maximum of four females.

Consult your DFO support biologist if you have questions regarding the use or application of these guidelines.

Table 1 – Examples of matrix spawning (modified from Eddy et al, 1996[1])

<table>
<tr><th>Sex Ratio</th><th>Spawning Protocol</th><th></th></tr>
<tr><td>Equal sex ratio</td><td>Spawn 2x2

<table><tr><td colspan="2"></td><td colspan="2">Female</td></tr><tr><td colspan="2"></td><td>X</td><td>Y</td></tr><tr><td rowspan="2">Male</td><td>A</td><td>AX</td><td>AY</td></tr><tr><td>B</td><td>BX</td><td>BY</td></tr></table></td><td>Even sex ratio allows an even-sided matrix.

.</td></tr>
<tr><td>Unequal sex ratio</td><td>Matrix structure depends on sex ratio

<table><tr><td colspan="2"></td><td colspan="2">Female</td></tr><tr><td colspan="2"></td><td>X</td><td>Y</td></tr><tr><td rowspan="3">Male</td><td>A</td><td>AX</td><td>AY</td></tr><tr><td>B</td><td>BX</td><td>BY</td></tr><tr><td>C</td><td>CX</td><td>CY</td></tr></table></td><td>Uneven sex ratio - matrix spawning ensures that all broodstock are used.</td></tr>
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[1] Eddy, D.L., R.W. Carmichael and T.A. Whitesel. 1996. Spawning protocols for the 21st century. p.3-11. In: D.D. MacKinlay (ed.). Proceedigs of the 47th Annual Northwest Fish Culture Conference, Dec. 1996, Victoria, B.C., MELP and DFO. 248 p.