Guidelines for In-Stream Placement Of Hatchery Salmon Carcasses For Nutrient Enrichment

Introduction

Historically, large numbers of salmonid carcasses provided entire watersheds with abundant nutrients and organic matter derived from the ocean. Recent research strongly supports the hypothesis that salmon carcasses play a key role in maintaining the productivity of salmonid systems and benefiting the aquatic and terrestrial ecosystem as a whole. Rearing juveniles consume salmon eggs, feed directly on spawned-out carcasses, and benefit from increased abundance of invertebrates and algal growth. The presence of carcasses in streams has been related to increased juvenile density, growth rate, body size, improved fish condition, improved overwintering survival and ultimately increased marine survival.

These guidelines have been developed to regulate the in-stream placement of hatchery salmon carcasses from Fisheries and Oceans Canada enhancement facilities where there is a desire and the capacity to distribute carcasses. The guidelines are not intended to enforce the distribution of carcasses, nor to replace harvest under an Excess Salmon to Spawning Requirements (ESSR) authorization.

These guidelines are meant to increase the overall benefits from carcass placement by minimizing disease risks and other concerns, providing general management strategies for carcass placement, and highlighting the interagency process to avoid conflicts with potentially affected groups and agencies. Numerous factors affect the benefits of carcass placement in streams. These include ambient nutrient content in treatment streams, abundance of native salmon spawners, presence of fish disease agents in carcasses, retention and distribution of carcasses in waterways, water temperatures, flow levels, light penetration, and predator / scavenger activity on carcasses by insects, fish, birds and mammals. These factors have been considered in the development of the guidelines

The guidelines were developed utilizing current relevant literature (Appendix 1), input from DFO fish health specialists and ecological research scientists, and guidelines prepared by thhe Washington Department of Fish and Wildlife.

Planning, Review, And Awareness

- Carcass placement plans must be reviewed by a DFO member of the Introductions and Transfers committee. Projects that meet the terms of the carcass placement guidelines will be issued a letter from the Department allowing the transport and deposition of carcasses. This letter must accompany all carcass movements.

- Carcass placement plans should be discussed with all relevant groups and agencies. These groups will include DFO local area staff in stock assessment, habitat, resource management, and Conservation and Protection (Fishery Officers), as well as local First Nations, stewardship groups, affected landowners or any other affected groups.

It is also important to contact the regional Ministry of Water, Land and Air Protection (MWLAP) office to ensure that carcass placement is coordinated with MWLAP inorganic nutrient enrichment projects. MWLAP should also be contacted if placement is considered in non-anadromous waters.

- Under the Water Act, downstream water users (primarily local municipalities), must be advised of activities that may potentially impact water quality of their withdrawals. Accordingly, Water Licensees on treatment streams should be advised prior to placement programs. Carcasses should be distributed in such a way so as to avoid or minimize impacts on domestic and other types of intakes or water supplies.

- Background material and signage may be provided to advise members of the public of carcass placement activity and its benefits.

Carcass Management and Condition

The placement of salmon carcasses in streams may pose a risk of disease transmission if carcasses of infected fish are used, if carcasses are moved to areas within the watershed that are normally not accessible to salmon, or if carcasses are moved to streams outside the watershed.

- Streams that receive carcasses are referred to as "treatment" streams and those that provide carcasses are referred to as "donor" streams. In general, no carcasses may be moved outside their natal stream because of concerns regarding disease transmission. However, in specific circumstances, movement of carcasses from the watershed to nearby streams *may* be considered if all of the following conditions are met:
- donor and treatment streams are geographically proximate and,
- treatment stream is within the zone of influence of the donor stock (i.e. adults may be straying from donor to treatment stream), and
- current disease history is available.

If sufficient information is not available, health testing of fish in the donor stream and treatment stream may need to be undertaken. Historical information can be obtained by searching the Pacific Biological Station (PBS) Fish Health Database; the Fish Pathology Program may be contacted at (250) 756-7057. Please note that wild fish surveys have not been conducted in many locations in recent years so that information contained in the database does not include current disease status for many salmon stocks.

- Only those fish killed with CO_2 or blunt trauma that show no visible evidence of serious disease should be used for carcass placement. Carcasses of recently dead salmon from managed spawning channels may also be considered for placement.

- Because of drug clearance times, and the length of holding, fish previously treated with an antibiotic or anaesthetic must not be used for carcass placement. However, fish treated with external chemicals that do not require a withdrawal period (e.g. Parasite S or Chloramine T) are considered safe for placement. If in doubt, contact the Fish Pathology Program.

- Carcasses may be frozen for later use. However, as freezing will not significantly reduce disease organism loads, it should not be considered a disease management tool.

Carcass Loading Density

- All salmonid carcasses are considered equal from a nutrient content basis. That is, required placement load may be calculated as biomass and then converted to fish numbers of the available species. For example, chinook carcasses may be substituted for coho, and vice versa. Where system-specific weight data are not available, the following average weights for returning B.C. salmon are provided for weight conversion.

Suggested Average Weghts for B.C. salmon *

Pink	1.5 kg	Steelhead	4.0 kg
Sockeye	2.5 kg	Chum	4.5 kg
Coho	3.0 kg	Chinook	8.5 kg

* Data sources: mean weights from B.C. catch statistics (J. Bateman, pers. comm.)

- The maximum carcass placement within a stream segment (including the areas into which carcasses drift from the distribution point), over the course of a spawning season should be 1.9 kg/m² based on Wipfli et al. (2003) and WDFW (in prep). In treatment streams with continuous escapement records, the carcass numbers may be reduced by the recent 10 year average for natural escapement to the treatment reach. For determining total carcass deposition maximums for streams used by more than one salmon species, the area historically available to each salmon species should be used to calculate the loading rate. Spawning timing should be factored into distribution schedules.

- Maximum loading densities may be adjusted to reflect the stream's carcass retention properties. Carcass retention in streams is affected by predator / scavenger activity, carcass transport during high flows, and abundance of in-stream structures to catch and retain carcasses. Accordingly, for streams with expected good carcass retention, maximum carcass densities may be reduced by the current spawner densities. For streams with expected poor carcass retention (high gradient, high flows, few pools and few in-stream structures), carcass loading densities need not be adjusted for current spawner densities.

Carcass Distribution

- The temporal and spatial distribution of carcasses should reflect the historic spawn timing and abundance of salmon in the treatment reach,.

- Carcasses should be placed in stream areas that are normally (or recently historically) accessible to salmon, (i.e., not above barriers). Carcass placement into inaccessible stream segments may be permitted where juvenile salmon of the same stock and species have been previously outplanted (e.g., colonized upper areas above impassable barriers) but consultation with regional MWLAP staff is necessary.

- Placement in the riparian zone is not necessary and often results in increased numbers of blowflies. (Reimchen et al, 2003.). Natural predators will remove carcasses from the treatment stream and distribute them in riparian zones.

- For streams with poor access (and low public use), a few accessible sites may be used for regular carcass placement. These sites should be inspected periodically to ensure adequate natural dispersion of carcasses. Where dispersal is poor, carcass loading should be reduced.

- Carcasses should be distributed in stable stream areas, where possible. This will help avoid rapid downstream transport of carcasses. Optimal sites include shallow backwater pools, side-channels, small headwater tributaries, areas with abundant woody debris and beaver-dam complexes. However, note that placing excessive numbers of carcasses in side pools with sluggish or intermittent water exchange may cause de-oxygenation (E.A. MacIsaac, pers. comm.).

- Carcass placement should be avoided or delayed during high flow events, especially where anchoring and/or riparian placement is not feasible.

- Timing of carcass placement is also important as nutrients should be made available to young salmon upon their emergence from the gravel. Placement timing may be early, mid or late, and may be used to influence the ecological response to loading within watersheds. For example, the use of carcasses from later runs of native salmon (fall and winter) may benefit the next growing season, provided that some nutrients are stored through the winter (Wipfli et al. 1999). Also, the use of carcasses from several species, each with a different run timing (e.g., early sockeye, mid-chum, late coho), will provide a longer nutrient pulse in the treatment stream than if only one or two species were used, each with a brief spawning period.

- If a treatment stream has a late natural spawning timing, carcasses from earlier runs to the treatment stream may be frozen and stored for later placement. The use of frozen carcasses is also convenient for long-distance transport.

- Carcass distribution schedule should consider anticipated problems of poor stream accessibility due to snow, high water, and other constraints.

Carcass Anchoring/Mutilation

- Carcasses may be tethered or anchored in place, especially in unstable, higher-flow areas in order to improve carcass retention.

- Where carcass anchoring is desirable, natural anchors (e.g., large woody debris, log-jams, beaver-dams) or bio-degradable tethers such as natural-weave ropes, should be used where possible. External identification tags should be removed from carcasses prior to their placement.

- Non-bio-degradable tethers should be collected and removed from the stream after carcass decomposition.

- Where frozen carcasses are used, they should be tethered in place (frozen carcasses float and may be readily transported downstream). Where tethering is not possible, it is preferred to thaw out at least one fourth of the frozen carcasses before distributing them in order to enhance carcass retention at the point of access.

- Where escapement enumeration programs will be conducted on treatment streams, carcasses should be cut in half or otherwise mutilated at placement, as directed by area stock assessment staff. This is crucial in order to avoid double-counting and ensure that enumeration programs are not affected.

Records of Carcass Placement

- Records of numbers and species of carcasses placed in treatment streams should be maintained in annual data summaries, including areas and dates of placement.
- Summaries should be provided to the contact member of the Introductions and Transfers Committee.

Appendix 1. References and Background Literature

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Wipfli, M. S., J. P. Hudson, J. P. Caouette, ad D. T. Chaloner. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase growth rates of stream-resident salmonids. Trans. Am. Fish. Soc. 132:371-381.

Placement of Hatchery Carcasses In Streams for Nutrient Enrichment

Historically, large numbers of salmon returned to spawn in their natal streams. After providing fertilized eggs for the next generation, the adults died leaving behind nutrient-rich carcasses. These replenished the entire watersheds with organic nutrients on an annual basis. A large variety of organisms (insects, fish, birds, mammals) fed on the carcasses, while aquatic and terrestrial invertebrates and plants thrived on the released nutrients.

Recent studies show that spawned-out salmon carcasses provide direct food to salmon juveniles and play a key role in maintaining the productivity of salmonid ecosystems. Rearing juveniles consume salmon eggs, feed directly on spawned-out carcasses, and benefit from increased abundance of aquatic invertebrates and algal growth. The presence of carcasses in streams is related to increased juvenile density, growth rate and body size; larger size of juveniles means improved overwintering survival and ultimately increased marine survival to maturity.

During the last century, numbers of salmon carcasses in streams and rivers have decreased. However, a portion of the spent salmon carcasses from several hatchery facilities in B.C are being used to replenish the nutrients in the ecosystem to help future generations of salmon. These carcasses are distributed in their stream of origin for nutrient enrichment.

Numerous factors affect the ultimate benefits of carcass placement in streams. These include original nutrient content in treatment streams, abundance of native salmon spawners, retention and distribution of carcasses in waterways, water temperatures, stream discharge levels, light penetration, and predator and scavenger activity on the carcasses. Proper timing of carcass placement is also important as nutrients should be made available to young salmon upon their emergence from the gravel and to older salmon juveniles inhabiting the stream. For example, the use of carcasses from several species native to the stream, each with a different run timing (e.g., early-run sockeye and late-run coho), will provide a longer nutrient pulse in the stream than if only one species were used.

Fisheries and Oceans Canada has developed guidelines to maximize the benefits from carcass placement, and address concerns over such issues as disease transfer and user conflict. For example, carcasses will be distributed in such a way as to minimize impacts on public-use areas and private property. No diseased or medicated fish will be used, and there will be restrictions on the placement of carcasses outside the watershed in order to minimize the risk of disease transfer. As well, carcass loading densities will reflect the historic spawning abundance and distribution in the treatment stream. Bio-degradable anchors may be used to tether carcasses in place, to improve their retention in streams.

By providing direct benefits to the future generations of salmon, the regulated placement of hatchery carcasses in streams will facilitate salmon stock rebuilding in British Columbia in a manner that is natural, environmentally friendly and effective.