NUTRIENT SUPPLEMENTATION

The following protocols for distributing carcasses, analogs, or fertilizer for salmonid restoration are in DRAFT form. When finalized, the process to be established will ensure that approved projects have all necessary governmental approvals. If you have questions or would like to propose a project, contact Hal Michael at WDFW at (360) 902-2659 or by email at michahhm@dfw.wa.gov. Alternatively, contact the Science Division of WDFW's Fish Program at (360) 902- 2800.

> *This protocol was developed independently from the Stream Habitat Restoration Guidelines and it appears here in its original format. It has not been altered to fit the format of the current document.*

PROTOCOLS AND GUIDELINES FOR DISTRIBUTING SALMONID CARCASSES, SALMON CARCASS ANALOGS, AND DELAYED RELEASE FERTILIZERS TO ENHANCE STREAM PRODUCTIVITY IN WASHINGTON STATE

The declining abundance in many wild salmonid populations in Washington can be attributed to a combination of factors including harvest and hatchery issues, hydroelectric operations, habitat degradation and loss, alterations to stream flow, altered basin hydrology, and reduced stream productivity. Restoration of salmon populations to levels capable of sustaining fully functional ecosystems and consumptive fisheries will require addressing all these issues; nutrient restoration addresses only a part of the overall problem.

There are currently four options being considered to increase the level of nutrients in freshwater ecosystems in order to restore ecosystem productivity to "historic levels". These are the application of fertilizers, the application of carcass analogs (processed fish cakes), the distribution of salmonid carcasses from fish hatcheries, and the allowance of increased levels of natural spawning by anadromous fish. These protocols and guidelines deal with nutrient recovery utilizing the first three methods; provision for increased spawner escapements will be dealt with in other forums.

The application of fertilizer to increase wild fish production has been conducted in the Pacific Northwest for years. Currently, there are two methodologies in use. One involves the introduction of liquid fertilizer into the water, either through intermittent dosages or through low-level drip. The second involves the placement of solid fertilizer pellets that dissolve at a predetermined rate, releasing nutrients over a period of months. Both methods have been shown to cause substantial increases in fish growth, survival, condition factors, and the like. Water quality monitoring associated with the application of these fertilizers has shown that they are rapidly taken up into the food chain and are generally not detectable in the water column outside of the treatment area/reach.

The use of carcass analogs is an emerging technology. The concept is that fish carcasses and other fish processing waste material is converted into a solid cake. The cake would be treated to kill associated fish pathogens. The advantage of the analog is that they are lighter in weight per unit of nutrient (when compared to carcasses) and they would present a much lower risk of pathogen transfer. The technology is

currently in development and testing.

The predominant method currently used to increase nutrients in freshwater and terrestrial ecosystems has been through the distribution of carcasses of salmonids that have returned to hatcheries.

In order to determine whether or not a system is in a state of nutrient deprivation/starvation, the natural spawning escapement level of a total of 1.9 kg/m² of surface area discussed in Wipfli et al. (2003). In order to mimic species-specific spawner densities, levels developed from information contained in Bilby et al. (2001) can be used. These levels are 0.15 kg/m² for coho and steelhead, 0.39 kg/m² for chinook, and 0.78 kg/m² for sockeye, pink, and chum. These numbers will be modified as research continues. Escapements below these levels will be assumed not to meet the minimal nutrient needs of the ecosystem. Other direct measures, such as smolt becoming older and/or smaller, analysis of benthic sediments, analysis of sequestration of marine derived nutrients in trees, etc. will also meet the assumption of lack of nutrients. For the application of fertilizer to streams the target concentration over the course of application will be 3-5 ppb of phosphorus based on Ashley and Slaney (1997) and Ashley and Stockner (2003). The application of fertilizer will require preliminary sampling of the waterbody to determine if or how much material needs to be added in order to avoid situations where phosphorus or nitrogen are excessive. Further, for the foreseeable future, the application of fertilizer will be done as part of a comprehensive study in order to avoid water quality problems.

GOAL OF NUTRIENT RESTORATION ACTIVITIES:

Increase the biological productivity of Washington's streams, riparian areas, upland areas, and estuaries by returning the nutrients originally supplied by anadromous fish carcasses back to the anadromous zone of spawning streams. Ultimately, the goal is the functional restoration of ecosystems supported by naturally spawning salmonids. Restoration of this functionality will require the restoration of the terrestrial and aquatic plant and animal communities in addition to simple anadromous fish restoration. It will also require the restoration of hydrologic cycles, restoration of the relationship between rainfall and streamflow, and restoration of aquatic habitat. Finally, restoration occurs when the nutrients are delivered to the ecosystem by naturally spawning fish and not through artificial methods.

OBJECTIVE # 1:

Enrich the nutrient supply to all aspects of an aquatic ecosystem (primary producers, scavengers, browsers, predators), enabling their population increases to be used for the trophic benefit of all interdependent species. This will result in increases in individual size, condition factor, and survival of juvenile salmonids living in the streams.

OBJECTIVE # 2:

Increase productivity in riparian zones and associated upland areas that will benefit the animals and plants that depend upon them.

OBJECTIVE # 3

Provide analogs or carcasses for direct consumption by juvenile fish and aquatic macroinvertebrates.

OBJECTIVE # 4

Provide alternatives to the use of anadromous salmonid carcasses where carcasses are not available.

OBJECTIVE # 5

Where appropriate, conduct water quality monitoring to document the uptake of nutrients while maintaining water quality for non fish-producing purposes. This monitoring should be structured to document not only the cultural oligotrophication of watersheds but demonstrate the uptake of the nutrients and the ecosystem benefits therefrom. Monitoring will be structured, where possible, to result in peer reviewed publication in appropriate scientific journals.

OBJECTIVE # 6

Increase the production of salmonid smolt and adults so that returning adult spawners can transport nutrients to the ecosystem.

PREMISES:

Actions taken to restore a stream's productivity through restoration of nutrients shall not be viewed as supplanting or supplementing natural spawning by wild salmonids. The ultimate goal is to provide the nutrients necessary to drive the ecosystem only through natural spawning by anadromous fish.

Streams identified for nutrient enhancement with carcasses must be within a designated Fish Health Management Zone (FHMZ), or smaller, that contains the source hatchery facilities.

No nutrients will be distributed in stream reaches formally identified as being impaired because of excess nutrients without the express approval of the Department of Ecology. The Department of Ecology will provide WDFW with a current list of impaired water body segments and, if appropriate, the specific timing (within the year) of that impairment.

All projects that exceed the identified biomass densities or those that introduce fertilizer will be part of a formalized research program designed to produce peer-reviewed publication. At the minimum the project water quality will be monitored as follows: One sample immediately upstream of the uppermost input point to serve as a control, one sample at the downstream end of the calculated treatment zone and one sample half a kilometer downstream from the point where calculations of nutrient spiraling (accounting for flow) suggest 100% consumption of the nutrient (Thomas et al. 2003). Samples will be collected monthly during the period of nutrient introduction and will continue for two months after the calculated date of pellet disintegration, after last application of liquid fertilizer, or after final degradation of carcasses or analogs. Measurements will be for parameters identified in the specific Memorandum of Agreement (MOA) developed for the project.

All projects will be covered by formal approval of the Department of Fish and Wildlife (WDFW) and Department of Ecology (DOE) through individual project MOAs. The MOA will accompany transport and depositing of materials.

All carcasses distributed under these protocols shall be from salmonids killed at WDFW or WDFW supported Coop hatcheries or from fish collected during a WDFW authorized wild brood stock capture project. Carcasses that are the result of mortality during holding at a hatchery, eggs

which are "picked" or otherwise determined to be non-viable following placement into incubation environment, and mortality of juveniles during rearing are covered by the National Pollution Discharge Elimination System (NPDES) permits and their disposal will follow the procedures described in the permit.

Once approved, the requested number of carcasses will be added to next year's hatchery planning processes. Since the number of fish returning to freshwater are controlled by many factors, some of which (ocean conditions) are outside of WDFW control, there can be no guarantee that a fixed number of fish will be available for distribution.

CRITERIA FOR TREATMENT STREAM IDENTIFICATION:

1) Treatment reaches shall be within the current anadromous zone of a watershed or within areas historically accessible to anadromous fish with exceptions based on specific research study needs.

2) Streams that have historic data sets and/or ongoing assessment projects that can be complemented by nutrient restoration will be given high priority in project planning. Conversely, streams with ongoing ecosystem assessment studies that would be adversely affected by nutrient enhancement will be avoided.

3) Streams or stream reaches where treatment ends less than two km upstream from municipal water supplies will be considered only with the expressed written concurrence of the water purveyor. Similarly, private domestic water diversions recognized by DOE will receive the same consideration.

4) Streams or stream reaches with identified water quality constraints for nutrients will be avoided; exceptions will be made only with written concurrence of the regulatory authority.

5) Treatment streams should have access points to the treatment reaches, (bridges, wet crossings, culvert crossings, etc.) to accommodate nutrient deposition, distribution, and monitoring.

6) Spawner index streams and smolt evaluation streams will not be selected for nutrient restoration unless potential impacts are resolved with the research or evaluation agency or organization.

7) Written landowner approval for access to deposit materials will be obtained.

8) Carcasses will be marked with an easily identified external mark if it is necessary to avoid having deposited carcasses being mistaken for naturally spawning fish.

CRITERIA FOR ADULT CARCASS DEPOSITION:

1) Temporal and spatial distribution should reflect historic anadromous spawn timing and abundance for a particular stream, for each species. For purposes of this program, all carcasses are considered equal from a nutrient per weight basis. Consequently, the actual distribution goal may be calculated as biomass and then converted to fish numbers. In practice, Chinook carcasses may be used as a substitute for coho, and vice versa, depending upon availability. Further, testing for pathogens, availability of access due to snow, etc. shall be considered when setting up distribution schedules.

2.) The maximum number of carcasses distributed within a stream segment will be 1.9 kg/m^2

based on Wipfli et al. (2003). In streams where estimates of the natural spawning escapement are routinely made, carcass numbers will be reduced by the recent 5-year moving average for natural escapement to the treatment reach. For determining total carcass deposition maximums, the area historically available to each species will be used to calculate the loading rates. This results in a separate calculation for each species/timing segment. Spawn timing will be factored into distribution schedules.

3) Carcasses will be used within designated watersheds or FHMZ as identified by WDFW Fish Health Specialists.

4) Carcasses will be used from stocks that have been screened for pathogens as prescribed in the Co-managers Disease Control Policy.

5) If necessary to avoid duplicate counting, interference with spawner enumeration, or other studies, carcasses used for nutrient enhancement will receive a distinctive external mark or tag. As noted in (1), species may be substituted in order to avoid the potential for enumerating a distributed carcass as natural escapement.

6) If necessary to avoid confusion with specific genetic sampling studies, carcasses will have an identifiable external mark or non-target species will be utilized.

7) All use of carcasses for nutrient restoration will follow the specific plan submitted by the applicant and approved in the formal project review process.

8) A copy of the annual project authorization will accompany transport and deposition of carcasses.

9) Deposition of carcasses should be avoided at flow levels (e.g. high flows/freshets) that would compromise the carcass placement objectives.

10) Artificial deposition of salmonid carcasses must not create a direct human health hazard.

11) Frozen carcasses can be used to approximate historic run (mortality) timing and to improve distribution to inaccessible stream reaches.

12) Distribution of carcasses should include shoreline and shallow water reaches of the stream.

13) Final Project approval or denial will occur at the WDFW Regional Fish Program Manager level after appropriate internal review. The Regional Fish Program Manager will ensure that Co-managers, the Department of Ecology, and other affected fish management entities have been consulted during project approval. Distribution of final approval/disapproval will be by the WDFW Science Division.

14). When there are concerns about within-stream fish pathogen transmission or concerns about contribution to an existing degraded water quality condition, carcasses may be applied to the terrestrial riparian zone (outside ordinary high water mark (OHW)) as long as they are not within 20 meters of OHW. This is done to meet the nutrient needs of terrestrial resources known to utilize carcasses.

15). Carcasses from fish treated with antibiotics or other chemicals such as anesthetics can be distributed if the fish met the labeled withdrawal period listed on the product label.

CRITERIA FOR CARCASS ANALOG DEPOSITION:

1) Temporal and spatial distribution should reflect historic anadromous spawn timing and abundance for a particular stream, for all species. For purposes of this program, the amount of analogs to be distributed will be converted to carcass biomass by correcting for the moisture/nutrient content of the analog. The actual distribution goal will be calculated as biomass and then converted to analogs.

2.) The maximum number of analogs distributed within a stream segment will be based on the target carcass levels developed from Wipfli et al. (2003) and then converted into specific nutrient levels based on analog composition. The target level is 0.0063 kg P/square meter of stream surface area. Summer low flow area will be substituted as a conservative density. In streams where estimates of the natural spawning escapement are routinely made, analog biomass can be reduced by the recent 5-year moving average for natural escapement to the treatment reach. For determining analog deposition maximums, the area historically available to anadromous species will be used to calculate the loading rates. Spawn timing will need to be factored into distribution schedules.

3) Analogs will be processed so that fish pathogens present in the raw material are destroyed during processing.

4) Use of analogs for nutrient restoration will follow the specific plan submitted by the applicant and approved in the formal project review process.

5) A copy of the final project approval will accompany transport and deposition of analogs.

6) Deposition of analogs should be avoided at flow levels (e.g. high flows/freshets) that would compromise the analog placement objectives.

7) Deposition of analogs must not create a direct human health hazard.

8) Final Project approval or denial will occur at the WDFW Regional Fish Program Manager level after appropriate internal review. The Regional Fish Program Manager will ensure that Co-managers, the Department of Ecology, and other affected fish management entities have been consulted during project approval. Distribution of final approval/disapproval will be by the WDFW Science Division.

CRITERIA FOR FERTILIZER DEPOSITION:

1) Application of fertilizer is designed to be a short-term enhancement of stream productivity directly tied to increasing smolt production and survival to spawning. The application of fertilizer targets only the dissolved nutrient fraction contained in a salmonid carcass. Consequently, extreme care must be taken to control application levels to achieve enhancement without degrading water quality. Applications should be timed to promote maximum uptake by the phytoplankton community.

2) The maximum amount of fertilizer to be deposited will be based on the recommendations of Ashley and Slaney (1997) and Ashley and Stockner (2003) which is to achieve an instantaneous Soluble Reactive Phosphorus level over the 120-day treatment of 3-5 micrograms per liter at average streamflow during application/release. Treatment reach will be defined based on the

Ashley/Slaney or Ashley/Stockner calculations or other methodologies as information is developed.

3) Determination of the need to apply fertilizer will be based on specific water quality sampling undertaken at least one year prior to the intended time of treatment. For lakes, sediment core studies showing historic phosphorus deposition and/or zooplankton communities will be used as justification for programs and for determining natural levels of nutrient input to the system.

4) The fertilizer formulation for use in streams must be Food or Pharmaceutical Grade. Liquid fertilizers, to be used only in lakes, shall be of agricultural grade and must be certified for use on food crops to be used. If a water right certificate has been issued for domestic water use from that water body, fertilizers must be Food or Pharmaceutical Grade. Chemical evaluation of fertilizer formulations must include screening for metals.

5) Use of fertilizer for nutrient restoration will follow a specific plan agreed to among water quality and fish management agencies. This plan will serve as a pre-deposition template for evaluating and directing carcass distribution requests or applications.

6) Transport and deposition of fertilizers will be accompanied by the appropriate approvals.

7) Placement of fertilizer should avoid flow levels that would compromise the placement objectives.

8) Each fertilizer application project will include a water quality-monitoring component. At the minimum, the proponents will be required to collect Soluble Reactive Phosphorus, Total Dissolved Phosphorus, Nitrate, Nitrite, and Ammonia samples from a point 50 m upstream of the uppermost fertilizing site, the midpoint of the treatment reach, the calculated bottom of the treatment reach, and 500 m downstream of the point where calculations expect nutrient spiraling to have consumed the added nutrients (Thomas et al. 2003). Samples will be collected monthly from one month before fertilizer deposition to two months after the calculated release of the last of the fertilizer. For example, if 120-day release formulation is used, samples would be collected on day number -30, 0, 30, 60, 90, 120, 150, and 180. The minimum detection level will be 1 part per billion. Sampling protocols will be designed to meet this detection standard.

9) Final Project approval or denial will occur at the WDFW Regional Fish Program Manager level after appropriate internal review. The Regional Fish Program Manager will ensure that Co-managers, the Department of Ecology, and other affected fish management entities have been consulted during project approval. Distribution of final approval/disapproval will be by the WDFW Science Division.

CRITERIA FOR TERRESTRIAL DEPOSITION OF CARCASSES

Deposition of carcasses or analogs in terrestrial areas within twenty (20) m of flowing water will be treated as if they were placed in the stream and will comply with the conditions listed above with regard to Fish Health Management Zones. It is desirable that, under normal deposition plans, some of the carcasses or analogs be applied terrestrially or in shallow water.

CRITERIA FOR ALL PROJECTS:

1) Approval is continuous as long as all operational requirements of a specific project are met.

2) Proponent must annually report to WDFW per the MOA. The report will indicate source of materials (carcasses, analogs, fertilizer), formulation (if appropriate), dates of deposition, location of deposition, and amount deposited. Proponent will indicate plans for the next year's activities and any changes proposed. This will be reported to the WDFW Science Division and will serve as the application for renewal for the subsequent year's program. In order to be automatically approved for the next year, the report must be received by June 30 following deposition. WDFW will ensure that interested agencies receive data summaries and results of monitoring. WDFW will annually issue an MOA, based on receipt of the annual report, which will be supplementary to the original approval document and must be present when carcasses, analogs, or fertilizers are transported and applied.

3) These criteria apply only to projects reviewed by the WDFW procedure. For carcass distribution projects, these protocols apply only WDFW operated facilities or to WDFW associated Coops. Carcasses from Federal or Tribal hatcheries can be covered by these protocols if the agency supplying the carcasses has met the necessary environmental review required by the appropriate governmental entity.

4) Applications will be reviewed and approved on a year-round basis. In order to have approval by September 1 it will be necessary to apply by July 1.

5). Each project will be required to conduct some level of annual monitoring. This monitoring will be tailored to resources available to the project applicant. Monitoring can include measurements of fish growth and abundance, insect population, growth, and diversity, predator and scavenger use, plant (aquatic or terrestrial) growth, etc.

APPLICATION AND REVIEW PROCEDURE FOR ALL PROJECTS:

1) Contact WDFW Fish Program Science Division for copies of the protocols and an application form. Specific technical assistance will be available from the Technical Assistance List accompanying the application package.

2) Completed application forms are forwarded to the WDFW Fish Program Science Division who will initiate the review process. The address is:

WDFW Fish Program Science Division
Nutrient Enhancement Section
600 Capitol Way N
Olympia, WA 98501-1091

For applications for carcass distribution ONLY:

A) The completed application will be reviewed by the WDFW Aquaculture Coordinator who will approve/deny use of carcasses.

B) WDFW Fish Health Manager will forward a copy of the application to the Northwest Indian Fisheries Commission for Co-Manager review. Following review by the Fish Health Manager the application will be forwarded to the appropriate Hatchery Complex Manager for review and approval. The application will then be returned to the Science Division.

C) Applications that are recommended, as Denied will be returned to the applicant with explanation. If changes in the application are recommended, the Science Division will contact the applicant to address the necessary modifications.

3) All completed applications (fertilizer, analog, and carcass) will be forwarded to the Regional Fish Program Manager for local review. Regional review will include signed approval by all WDFW Regional Programs, Treaty Indian Tribes within whose Usual and Accustomed Area the application is proposed for, landowners controlling access to application sites, and the Department of Ecology Regional Office.

4.) Following regional review the Regional Fish Program Manager will approve or deny the application.

5.) The approved application and review forms will be returned to the Science Division for distribution. An MOA will be developed for each project based on the approved application and will be append to the WDFW approval.

REFERENCES

Ashley, K. I., and P. A. Slaney. 1997. Accelerating recovery of stream, river, and pond productivity by low-level nutrient replacement, Chapter 13 *1n* Slaney and Zaldokas, (editors*).* Fish habitat rehabilitation procedures. Watershed Restoration program, MOELP, Vancouver BC.

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Bilby, R. E., B. R. Fransen, J. K. Walter, C. J. Cederholm, and W. J. Scarlett. 2001. Preliminary evaluation of the use of stable isotope ratios to establish escapement levels for Pacific salmon. Fisheries 26:6-14.

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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. Transactions of the American Fisheries Society 132:371-381.