

Nutrient Enhancement

Peter A. Bisson, Research Fish Biologist

USDA Forest Service, Pacific Northwest Research Station

Olympia, WA 98512-9193

(360) 753-7671, pbisson@fs.fed.us

Using nutrient additions in the Pacific Northwest to enhance salmon began in Alaska in the 1930s, when inorganic nutrients (primarily phosphorus) were added to oligotrophic lakes to improve the growth of young sockeye salmon. The technique of lake fertilization was adopted by salmon managers in British Columbia in the late 1960s and became one of the cornerstones of B.C.'s Salmonid Enhancement Program. Studies of large sockeye-producing lakes such as Great Central Lake on Vancouver Island showed nutrient additions improved growth, which resulted in greater smolt-to-adult survival. Experiments involving nutrient enrichment of streams and rivers from 1960-1990 were rare, but most demonstrated some productivity benefits for juvenile salmonids. In the 1990s, application of stable isotope techniques for documenting the contribution of marine-derived nutrients to freshwater food webs showed that nutrients from salmon carcasses were an important contributor to aquatic plants and animals, as well as to riparian vegetation and scavenging wildlife. Since then, hatchery carcass distribution programs have become widespread, and more recently the development of carcass "analogs" from fish processing facilities have facilitated the distribution of marine-derived nutrients to remote locations. In spite of the region's eagerness to embrace nutrient enhancement as a cost-effective restoration technique, very few studies have actually demonstrated that carcass or carcass analog placement results in the magnitude of productivity responses that have been observed in some of the Canadian sockeye lakes. Additionally, concerns have been expressed about the potential of carcass distribution programs to transmit fish diseases or persistent organic pollutants to streams, and to increase nutrient loading to downstream areas where additional nutrients are not wanted. Because nutrient enhancement in streams and rivers represents a largely unproven restoration technique at present, and because other aspects of nutrient additions (particularly with carcasses or seafood products) have been inadequately studied, carefully monitored field trials are warranted before the technique is implemented widely.

Selected References

- Bilby, R. E., B. R. Fransen, P. A. Bisson, and J. K. Walter. 1998. Response of Juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses in two streams in southwestern Washington, U.S.A. *Canadian Journal of Fisheries and Aquatic Sciences* 55:1909-1918.
- Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Percy, C. A. Simenstad, and P. C. Trotter. 2001. Pacific salmon and wildlife – ecological contexts, relationships, and implications for management. Pages 628-684 in D. H. Johnson and T. A. O'Neil, editors. *Wildlife-habitat relationships in Oregon and Washington*. Oregon State University Press, Corvallis, Oregon.

- Claeson, S. M., J. L. Li, J. E. Compton, and P. A. Bisson. 2006. Response of nutrients, biofilm, and benthic insects to salmon carcass addition. *Canadian Journal of Fisheries and Aquatic Sciences* 63:1230-1241.
- Compton, J. E., C. P. Andersen, D. L. Phillips, J. R. Brooks, M. G. Johnson, M. R. Church, W. E. Hogsett, M. A. Cairns, P. T. Rygiwicz, B. C. McComb, and C. D. Schaff. 2006. Ecological and water quality consequences of nutrient addition for salmon restoration in the Pacific Northwest. *Frontiers in Ecology and Environment* 4(1):18-26.
- Hyatt, K. D., and J. G. Stockner. 1985. Responses of sockeye salmon (*Oncorhynchus nerka*) to fertilization of British Columbia coastal lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 42:320-331.
- Naiman, R. J., R. E. Bilby, D. E. Schindler, and J. M. Helfield. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. *Ecosystems* (2002)5:399-417.
- Pearsons, T. R., D. D. Roley, and C. L. Johnson. 2007. Development of a carcass analog for nutrient restoration in streams. *Fisheries* 32(3):114-124.
- Sanderson, B., and P. Kiffney. 2003. Assessment of three alternative methods of nutrient enhancement (salmon carcass analogs, nutrient pellets, and carcasses) on biological communities in Columbia River tributaries. 2001-2003 Technical Report, Project No. 200105500, BPA Report DOE/BP-00007621-2. 20p.
- Wilzbach, M. A., B. C. Harvey, J. L. White, and R. J. Nakamoto. 2005. Effects of riparian canopy opening and salmon carcass addition on the abundance and growth of resident salmonids. *Canadian Journal of Fisheries and Aquatic Sciences* 62:58-67.