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Technical Memorandum

Date: July 9, 2007 Project Number: 1582.014/MM101

To: James Reilly, Stetson

From: Paul DeVries, Dudley Reiser

Subject: SWRCB Instream Flow Policy: GIS-Analysis Criteria for Upstream Distribution Limit of Steelhead

cc: Tracey Kenward

Implementation of specific elements of the Policy will involve identifying the upstream extent of anadromy for steelhead and coho. R2 made an initial recommendation based on our general experience that on a regional basis, steelhead passage would likely be precluded by reaches 500 feet or longer over a longitudinal slope continuously greater than or equal to 8%. We have subsequently conducted a literature review and contacted various researchers from the U.S. Forest Service and National Marine Fisheries Service (NMFS) to refine these criteria as necessary. Our review of salient information in the following citations that we identified suggests that a slope of approximately 12%, as discernable over 100 m using digital elevation models (DEMs), would likely limit upstream passage of steelhead in the Policy area, and therefore by default, coho and Chinook salmon which generally are bound lower in Policy area watersheds. This corresponds to the limiting value used to define intrinsic habitat potential for steelhead in the Policy area by NMFS (Agrawal et al. 2005). Some literature from wetter climates suggest that passage would be possible in even steeper streams, but in general, for the Mediterranean setting of the Policy area, we believe a stream gradient of about 12% or greater would likely limit upstream passage regionally.

Relevant references and summary findings include:

- Agrawal, A., R.S. Schick, E.P. Bjorkstedt, R.G. Szerlong, M.N. Goslin, B.C. Spence, T.H. Williams, and K.M. Burnett. 2005. Predicting the potential for historical coho, Chinook, and steelhead habitat in northern California. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-379. Southwest Fisheries Science Center, Santa Cruz CA.
    - Maximum stream gradients below which the IP model considered habitat availability to be negligible were 5% (coho), 12% (steelhead), and 3.5%

(Chinook). The 10 m DEM was able to discern most major known barriers to upstream migration, but not smaller barriers that may exist.

- Bryant, M.D., N.D. Zymonas. and B.E. Wright. 2004. Salmonids on the fringe: Abundance, species composition, and habitat use in high-gradient headwater streams, Southeast Alaska. Transactions American Fisheries Society 133: 1529-38.
    - Results indicated importance of maintaining access to high gradient streams. Coho and steelhead juveniles were found in SE Alaska coastal streams with up to 16% gradient over 100 m long reaches.

- Buffington, J.M., D.R. Montgomery, and H.M Greenberg. 2004. Basin-scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness in mountain catchments. Canadian Journal Fisheries and Aquatic Sciences 61: 2085-2096.
    - Step-pool channel morphology may support spawning habitat. Range of gradients containing this morphology extended up to about 9.5%; the cascade channel morphology, which is unlikely to support significant spawning habitat, had slopes ranging about 4.3% and higher (c.f. Figure 3 in paper; error in interpretation ~±0.1%).

- Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17(1): 66-80.
    - Empirical evidence from published studies (listed in Agrawal et al. 2005) was interpreted to develop suitability index scores for gradient for steelhead and coho habitat. Suitability was negligible at gradients in excess of 7% and 5%, respectively (depicted in Figure 2 of paper). Streams with gradients less than this had a relatively higher intrinsic habitat potential.

- Davies, J.R., K.M. Lagueux, B. Sanderson, and T.J. Beechie. 2007. Modeling stream channel characteristics from drainage-enforced DEMs in Puget Sound, Washington, USA. Journal American Water Resources Association 43(2): 414-426.
    - Channels with bankfull widths greater than 10 m and gradients less than 4% in general terms have greatest potential to support Chinook habitat.

- Montgomery, D.R., E.M. Beamer, G.R. Pess, and T.P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Canadian Journal Fisheries and Aquatic Sciences 56: 377-387.
    - Spawning in localized lower gradient areas may allow a generally steep stream to support salmonids.

- Nagel, D., J. Buffington, and D. Isaak. 2006. Comparison of methods for estimating stream gradient using GIS. http://www.fs.fed.us/rm/boise/research/gis/presentations/Nagel_NWESRI06_StreamGradient.pdf.
    - Most appropriate interval for measuring stream slope in higher gradient areas appears to be about 100 m when using 10 m DEM data.

- Sheer, M.B., and A. Steel. 2006. Lost watersheds: Barriers, aquatic habitat connectivity, and salmon persistence in the Willamette and Lower Columbia River basins. Transactions American Fisheries Society 135: 1654-1669.
    - Spawning habitat found for Chinook and steelhead in streams with gradients less than 7% and 12%, respectively. Gradients above 16% and 20% were assumed to block passage based on unpublished data cited from WDFW.