A Review of the Role of Small Tributary Streams as Salmonid Habitat

Background and Purpose

At the August 2018 meeting, the Forest Practices Board directed the Adaptive Management Program Administrator (AMPA) to develop supporting scientific documentation that reflects the state of the science pertaining to the use of small tributary streams by fish. The language from the motion is as follows:

" I move the Forest Practices Board directs staff to work with each of the proponents to clarify each alternative, including PHB's as they relate to above and within the anadromous floor. The Board further directs staff to work with stakeholders to ensure the analysis process is transparent to all caucuses. The Board further directs the AMPA to convene the authors of the January 2018 report from the science panel to update the report to reflect all perspectives and supporting science regarding tributaries."

The purpose of this document is to review the scientific literature that pertains to the use of tributary streams by both resident and anadromous salmonids and provide the Board with a comprehensive summary of the scientific literature on the role of small tributary streams as salmonid habitat. In this document, we refer to small tributary streams as streams that are 1st -3rd order streams generally less than 2m wide and consistent with the Washington Forest Practices Act (WAC 2013) definition for fish habitat, we define small tributary streams as streams that enter a larger stream in which resident and/or anadromous fishes may use during some part of their life cycles if this habitat is accessible. They may or may not contain perennial flowing surface water and their connection to a larger stream may be year-round or seasonal.

Case Studies of Small Streams as Fish Habitat

For resident trout and char and for anadromous salmonids that spend more than a few months of their lives in fresh water, the availability of aquatic habitat suitable for survival and growth is critical for successful freshwater rearing. Salmonids exhibit a variety of movements to different parts of a watershed in response to their life history requirements (Northcote 1978) and it is common for a variety of directed movements to be expressed within a single species (Quinn 2018) as a way of "spreading the risk" within the population and ensuring that a portion of

individuals will survive in an environment prone to multiple types of disturbance. Movements can be upstream, downstream, or laterally into small tributaries in which fish are not normally found. Transitional occupancy of temporarily suitable habitats is an important adaptation by salmonid fishes to living in unpredictable stream ecosystems (Schlosser and Angermeier 1995). In the Pacific Northwest, tributary streams (<2m bankfull width) are important habitat for many salmonids and may constitute a significant proportion of the habitat available to them (Rosenfeld et al. 2002). Small streams play an important role in the life history of anadromous fish by providing important spawning and rearing habitat for various life stages of salmon *Oncorhynchus spp*., Steelhead *O. mykiss* and anadromous Cutthroat Trout *Oncorhynchus clarkii*. Coho Salmon *O. kisutch*, Steelhead and anadromous Cutthroat Trout are often found in streams ranging from small tributaries to mainstem rivers where they spawn and rear before migrating to the ocean (Cederholm and Scarlett 1981; Hartman and Brown 1987; Brown and Hartman 1988). Small tributaries have been shown to provide important overwintering habitat for both Steelhead (Cederholm and Scarlett 1981; Bramblett et al. 2002) and Coho Salmon (Bustard and Narver 1975; Peterson 1982; Brown and Hartman 1988; Nickleson et al. 1992), and Cutthroat Trout (Bustard and Narver 1975b) in a variety of Northwest streams.

Similarly, small streams are also important habitat for many resident trout and char *Salvelinus spp.* Resident trout show diverse life history strategies that often include spending considerable time in headwater streams (Fausch et al. 2002). Many of these fish may move relatively small distances that span less than a kilometer and move primarily between habitat units for feeding (Hilderbrand and Kershner 2000a; Schrank and Rahel 2004) while other fish are more migratory, using small tributaries for rearing as young of year and juveniles and eventually moving downstream into lake systems or move into larger rivers (Gowan and Fausch 1996, Dunham and Rieman 1999, Colyer et al. 2005, Muhlfeld and Marotz 2005). Small tributaries may provide important refugia for young trout where they can avoid larger predators and competition with older year classes (Louison and Stelzer 2016). For example, Louison and Stelzer (2016) observed that young-of-the-year Brown Trout *Salmo trutta* were able to use perennial first order streams for the first several months and likely immigrated into these streams from spawning areas.

Small tributary streams may support high densities of juvenile Cutthroat Trout in a watershed (Murphy et al. 1986, Rosenfeld et al. 2000). Stream habitat in these smaller streams is influenced by a number of factors. In a study of Cascade Mountain streams in Washington, fish use of these small tributaries was constrained by limited pool habitat, decreasing channel width, and sharp increases in channel gradient, but Cutthroat and Rainbow Trout *O. mykiss* did access streams with gradients up to 22% and were common where gradients exceeded 10% (Latterell et al 2000). Steep channels that contained abundant pools were more likely to contain fish, and pools provided a jumping point to access upstream habitat (Adams et al. 2000). In small streams in southeast Alaska, Coho Salmon, steelhead and Cutthroat Trout were found in accessible habitats above 15% gradients and ,while Coho Salmon did not appear to spawn in these high gradient reaches, spawning Dolly Varden char *Salvelinus malma* did occur (Bryant et al. 2004, Wissmar et al. 2010). In Washington State streams, fish have been observed in headwater stream segments with overall slopes as steep as 35% (J. Silver, Hoh Indian Tribe, Forks, WA, 1996, unpublished data; D. Collins, Washington DNR, Olympia, 2006, unpublished data), and in stream segments of 25% and steeper in Oregon (Connolly and Hall 1999).

The use of small, headwater tributaries often has a seasonal component related to flow availability and freshet timing. During seasonal runoff, fish may move into small tributaries to spawn or may use these tributaries as refugia from high flows (Bramblett et al 2002, Bryant et al. 2004). Other movements into small streams during these periods may be related to exploratory movements where fish look for new and possibly unoccupied habitats (Dolloff 1983, Decker and Erman 1992). For example, during times of low flows in southeast Alaska streams, juvenile Steelhead left small tributaries for larger streams while young Dolly Varden were year-round residents (Bramblett et al. 2002). In Carnation Creek, British Columbia Coho Salmon and trout (steelhead/cutthroat) used small tributaries in different ways during different seasons (Hartman and Brown 1987). Both young Coho and trout entered tributaries more in autumn and early winter. In contrast, Coho tended to leave tributaries more in late winter and early spring while the numbers of trout entering and leaving were about the same. Spawning trout entered tributaries from March to May. Depending on the species, salmonids may leave smaller tributary streams for downstream habitats with more water or in some cases be stranded in deeper pool habitats until fall or until seasonal rains arrive (Wiggington et al. 2006, Ebersole et al. 2006).

There are ontogenetic differences in preferred habitats of Cutthroat Trout. Moore and Gregory (1988) found that Cutthroat Trout fry were more commonly associated with low-velocity stream margins in the Cascades, while larger (older) Cutthroat Trout were more associated with pool habitat (Bisson et al. 1988; Rosenfeld 2002).

While seasonal use of habitats may occur in some small tributaries, the movements of trout to the most upstream portions of the drainages may not change dramatically unless changes in physical habitat or stream flows occur. Cole et al. (2006) found that most fish distribution boundaries did not change significantly in eastern Washington streams during the summer months over two years and most changes that did occur were less than 50 meters. Streamflow regimes for the two years surveyed were similar and reflected lower than average discharge at these locations. Higher winter and summer stream flows may influence the location of these boundaries when fish are able to move upstream during favorable physical conditions. Transient barriers that consist primarily of large woody debris are destroyed and reformed during high stream flow events and may influence fish movement. Seasonal variation in stream flow may potentially cause shifts in fish distribution and have yet to be adequately measured (Cole et al. 2006). For example, in a recent survey of Falls Creek, Washington (Deschutes River tributary) by Weyerhauser Company personnel, surveyors noted fish above a potential barrier in a seasonally flowing tributary stream during spring sampling (Figure 1). Observations of inaccessible habitat and diminished streamflow suggest these fish were most likely forced to move to more favorable locations immediately downstream in Falls Creek (Figure 2).

Figure 1. Confluence of a tributary of Falls Creek on the Vail Tree Farm, August 29, 2018. In a recent survey, fish were found 30 m upstream of this location (Jason Walter, Weyerhaeuser Company, personal communication).

Figure 2. Falls Creek (Type F) immediately adjacent to tributary in Figure 1 (above).

Intermittently flowing tributary streams during summer can provide important habitat opportunities for salmonids during periods of the year when discharge increases. Rainbow Trout preferentially spawned in Kilm Meadow Creek, an intermittent tributary of Sagehen Creek, California, during the spring and young trout were able to emerge and emigrate out of the stream before summer low flows caused the stream to become intermittent (Erman and Hawthorn 1976). Juvenile Coho that used intermittent tributaries in Oregon streams had higher overwinter survival than Coho from perennial tributaries (Wigington et al. 2006). Residual pools that remained available during the summer months were able to sustain young Coho when streams became intermittent. As streamflows resumed in the fall, other Coho from the mainstem moved into these streams. Similarly, Ebersole et al. (2006) observed that young Coho utilizing intermittent streams had higher growth rates and migrated as larger smolts in tributaries of the West Fork Smith River. Environmental conditions related to rainfall also may influence how successful each

cohort of young fish may be. Drought conditions during the summer low flow period may cause many stream habitats to dry up that may be available in wetter water years (Hwan et al. 2017). Age 0 Coho and Steelhead did better in wetter precipitation years in small intermittent tributaries in California and Coho had slightly higher survival.

An often-overlooked role of small tributary streams is their importance in providing cold water refugia and as a source or recruitment after catastrophic events such as debris flows or wildfires. Lamberti et al. (1991) documented the recolonization of stream habitat by cutthroat trout after a debris flow occurred in Quartz Creek, Oregon. They found that while local densities of trout were severely impacted by the debris flow, the presence of trout in small tributaries (unimpacted by the debris flow) contributed to the recovery of Cutthroat Trout the following year. In a review on the effects of wildfire on stream fish, Gresswell (1999) found that recolonization of streams after high severity fires is often rapid where fish populations outside these basins are in proximity to these watersheds and movement among streams is not limited.

The connections of these smaller tributaries to large streams may be particularly important where small stream habitat provides higher quality habitat than adjacent streams that have been significantly altered by disturbance (Tschaplinski and Harman 1983, Ebersole et al. 2006). For example, some tributaries of Type F waters may not used by fish during any season of the year due to a blockage at the tributary mouth or to unfavorable physical conditions (e.g., gradient, lack of rearing habitat and seasonal flow) in the tributary channel. However, over time accessibility factors or channel habitat can change in such a way that what were previously uninhabitable streams provide conditions that are favorable to fish occupancy, and conversely, tributaries that can be used by fish at present may experience changes that render them unfavorable in the future. Changes that determine whether small tributaries can be used by fish are typically related to disturbances such as exceptionally high flows associated with catastrophic flood events such as rain on snow floods, debris flows from landslides or wildfires, and windstorms. Such episodic disturbances are erratic and can occur infrequently (decades to centuries), but their overall effect in drainage systems is to create a mosaic of streams suitable for fish that changes in response to local disturbance regimes. This is illustrated conceptually in the Figure 3 adapted from Penaluna et al. (2018).

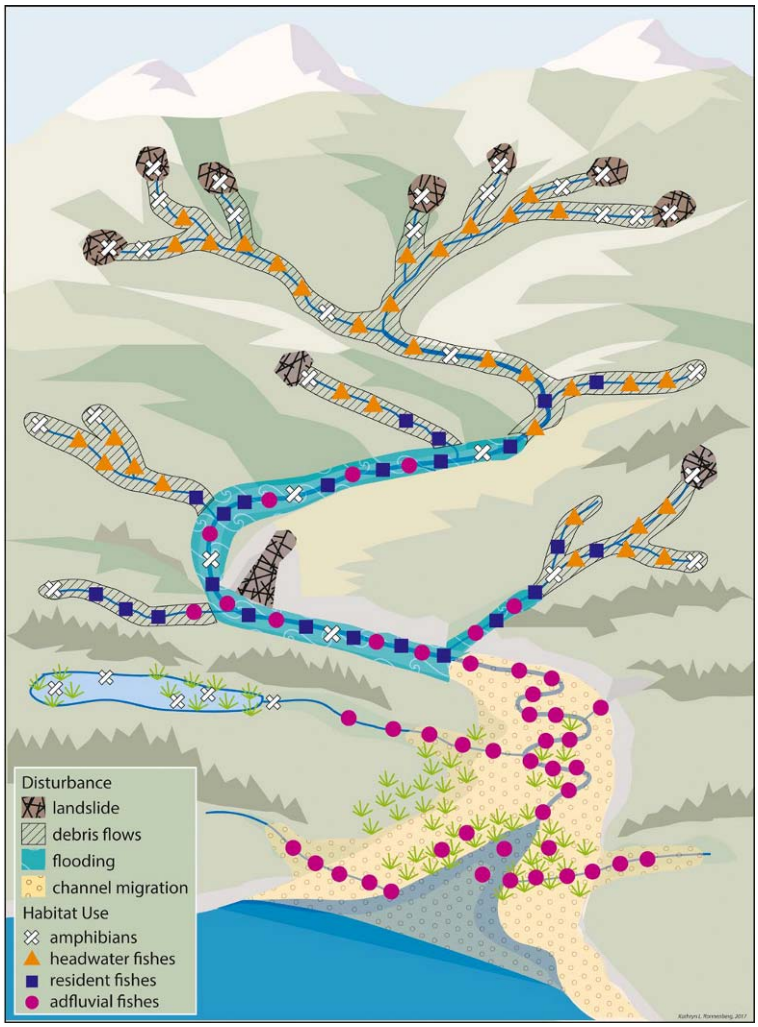

Figure 3. (From Penaluna et al. 2018) Generalized natural disturbances in a river network (modified from Montgomery 1999). Overlaid are types of aquatic species that are generally adapted to each area. The actual occurrence of a disturbance event depends on local conditions, including topography and soil type, and the legacy of past natural and human disturbances, such as the extent to which best management practices have been implemented regarding riparian buffers, conservation tillage, and culvert upgrades.

Conclusion

Small tributary streams can provide important habitat for stream-dwelling salmonids if they are accessible at some point during the hydrologic year. Anadromous fish may use small tributaries for spawning and rearing habitat, even in some cases when those streams are seasonally

intermittent. Small tributary streams are also important habitat for resident and migratory trout and serve similar functions as spawning, rearing, and overwintering habitat. An important role of small tributaries is their being part of well-connected drainage networks that allow for the passage of fish among rivers and tributaries. Connectivity facilitates rapid recolonization of streams by salmonids following large disturbances and provides access to refugia by fish during the disturbance events themselves. While differences in the upstream extent of population distribution may be limited by barriers caused by gradient, waterfalls or stream size, fish will continually explore new habitats when they become available and colonize suitable habitats when accessible. This includes small tributaries that may not be inhabited by fish during typical stream survey periods (spring or summer), but may constitute important habitats at other times of the year. Management strategies that take the dynamic nature of headwater tributaries into account are likely to be more robust to future changes than those that consider existing conditions to be permanent.

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