Step 2 H-integration effects tables – Sammamish River population **11-17-09**

SAMMAMISH POPULATION – All naturally-produced Sammamish and Issaquah Hatchery-produced Chinook salmon are currently included in the Puget Sound ESU and are protected under the ESA based on a change in listing determination dated June 28, 2005, with hatchery production representing an indistinguishable component of the Sammamish population according to NOAA-F.

Abundance

Samm Action	Habitat	Harvest	Hatchery
Effect	Abundance of the naturally-spawning population has been in decline (indexed to Bear/Cottage), affected by long term reduction in habitat capacity from reduction in length, area, flow, and other habitat impairment affecting capacity in Issaquah Creek, Sammamish River, tributaries to the lakes, and lake or other rearing environments. The Sammamish valley historically was a wetland-stream meander complex with seasonally inundated hardwood forests. Channelization and straightening of the Sammamish River has shortened its historical length by 9 miles. Base flow of many streams has been reduced by decreased infiltration, wetland losses, channelization, water withdrawals, urbanization, and drainage projects. Water inputs from out of basin sources (via septic systems and irrigation) provide low-flow augmentation; however, while this 'imported' water may buffer base flow reduction in some areas, it is not likely to have reversed the trend toward lower base flows. On the other hand, headwater areas of core subbasins (Bear and Issaquah) are well protected in large public ownership. Hydrologic change due to land use has been mapped and characterized by King County and others (e.g., Booth and Jackson 1997). Land use has resulted in higher peak flows in most tributaries in the basin. Between 1983 and 2007 the annual adult returns of Chinook to Bear Creek averaged approximately 280 fish. The NMFS BRT[1] estimated the 5-year geometric mean abundance (1998-2002) of 331 fish returning to spawn, though more recently (2003-2007), the geometric mean for Chinook in the Bear Creek Basin is 173. Returns to other NLW creeks range between one to 25 fish, except for Kelsey Creek, which averaged 138 adult returns in 1999 and 2000. Abundance below the Issaquah hatchery rack averaged 889 spawners between 2000-2007 (including E. Fork). Population persistence (in Bear, Cottage, Little Bear, North and Kelsey creeks among other creeks) may be dependent upon hatchery production given habitat degradation. Overall, the naturally-produced abundance of this population is considered extremely low for long term viability in the natural environment, and this overall conclusion was drawn prior to knowing the hatchery composition on the spawning grounds. Other habitat alterations (such as the locks-diffuser wells, saltwater drain) affect adult/smolt abundance directly. Potentially high direct and cascading effects are likely to exist, worsened with behavioral response to high temperatures and low dissolved oxygen (DO). Smolt slides at the locks have improved passage survival in recent years. Capacity in migratory areas has been altered from historical habitat with the disconnection of the Cedar from the Black and Duwamish Rivers, as well as the elimination of historic salt marsh estuarine habitat. The lake shorelines and nearshore habitat in WRIA 8 and Puget Sound is degraded and pocket estuaries or margin habitats have been eliminated or greatly altered. Other possible low abundance risks include depensatory (Allee) effects. In summary: EDT modeling suggests abundance is only 10% of historical numbers due to habitat effects. In 2005, NOAA determined the critical habitat designation for the Puget Sound Chinook ESU and excluded from designation the Lake Sammamish watershed based on a low conservation value and that "*the economic benefits of exclusion outweigh the benefits of designation"* FR Vol.70, No. 170 , September 2, 2005.	No directed terminal harvest occurs on Bear Creek bound Chinook; in some years, recreational and Tribal harvest is directed at surplus Issaquah hatchery Chinook in Lake Sammamish. Muckleshoot Tribe voluntarily closed its directed WRIA 8 Chinook harvest in 1994, outside of Lake Sammamish harvest, and has not exercised its treaty rights for Chinook for the last 15 years except for small numbers of incidentally caught fish (total incidental harvest in WRIA 8 coho and sockeye fisheries has ranged from about 500 to 1600 Chinook between 2004-2008 (Stolnack 2009) which on average represents an impact on potential basin escapement of about 4%. Over 85% of incidental catch is reported to be hatchery fish.). Harvest methods are not selective for marked and unmarked Chinook. Selective fisheries occurred in the pre-terminal sport fisheries 2007 and 2008. Harvest impacts on spawner abundance are currently less than in the past: total exploitation of South Sound Fall Chinook was reduced from 83% (avg. '82-'99) to 60% (avg. '00-'05). Lake Washington terminal harvest was further reduced to protect Cedar Chinook and total exploitation has been ~ 50% since the early 1990s. Reduced harvest and higher returns have not appeared to increase overall spawner abundance in other Sammamish tributaries, though it has contributed to increased abundance in Issaquah Creek.	Production of Chinook from the Issaquah Hatchery began in 1936 using Green River stock, a tributary that was disconnected from the Cedar/ Sammamish system in 1913. Current releases are 2 million smolts (30% lower than 1980-90 levels), but returns have been strong since 2001 (averaging 9,100 to the hatchery rack between 2001 and 2007). Between 1997-2000 returns to Issaquah hatchery averaged approximately 3800 Chinook. Passage of fish above the hatchery rack (2000-2007) has varied from 175 to 9554 adults (average of 3819 spawners above rack), and management practices are changing to reduce upstream passage numbers, in keeping with the size of the basin. Hatchery strays contribute significantly to current abundance in Sammamish tributaries, and likely have since 1936. Annual spawners have been 63 -78.9% marked (2004-2007) in Bear/Cottage and averaged 92.3% in Issaquah Creek. The juvenile contribution from hatchery origin spawners may buffer the population from effects of predation and other factors, assuming total juvenile abundance (esp. hatchery releases) doesn't trigger competition in river or lakes. Information is not available related to competition or disease transmission between hatchery and natural origin Chinook in the watershed. Large hatchery surplus has been released to Issaquah Creek in the past to spawn naturally. In 2007 only 175 fish (all NORs) were released above hatchery and 11,600 HORs were surplussed. Program size exceeds current harvest + broodstock requirements + Issaquah Creek capacity when survival rates are high. However, in some years total returns have been close to the hatchery broodstock goal.
Certainty of effect	Strong consensus that habitat limits abundance.	Strong consensus that current harvest is not detrimentally affecting overall Sammamish	Agreement exists that hatchery strays increase the number of naturally-spawning Chinook in the Sammamish population.

[1] NMFS BRT = National Marine Fisheries Service Biological Review Team

		abundance.	
Questions/ Risks?	Does hatchery production support naturally-spawning population persistence because habitat cannot? What role do upstream migration barriers (thermal, flow, or physical) play in the abundance of Chinook on the spawning grounds, e.g., in the Bear Creek Basin? What is the timeline for remeandering the Sammamish River and restoring associated wetlands? What has been the net gain in impervious surface area in the basin by tributary since the 2005 Recovery Plan was submitted to NOAA?	Is there an opportunity to selectively harvest w/o limiting abundance in other Sammamish tribs? What role has a reduction in Canadian harvest had in improving the abundance of Chinook on the spawning grounds?	What are Sammamish pop'n effects on the Cedar pop'n?

Productivity

Samm Action	Habitat	Harvest	Hatchery
Effect	Estimated fry/smolt production per adult female in Bear/Cottage creek was between 50 and 184 total juveniles (2000-2007 brood years – Kiyohara and Zimmerman 2009). In recent years, PIT tagged fish from Bear Creek are recaptured at the locks at a higher rate than Cedar River smolts (Devries 2008), however, these results may be confounded by differences in the study's tag timing and smolt outmigration timing in these two streams (Eric Warner, pers. comm.). Estimates of survival from eggs to migrants to the Bear Creek trap are low (1.0 to 4.1% for both fry and parr [2000-2007 brood years – Kiyohara and Zimmerman 2009]). Productivity is impaired due to land use and instream habitat conditions including increased peak flows and elevated egg scour mortality, reduced habitat complexity, Sammamish River thermal stress and habitat conditions, lake environments (e.g. food availability/quality), elevated predation including by cutthroat trout whose numbers have increased due to land use related changes in peak flows, and other causes (e.g. toxic contaminants, disease). Shoreline habitat quality changes in lakes and the Sammamish River/Ship Canal affecting migrant life history likely influence total productivity (see Tabor et al. 2006). From results of EDT analysis, freshwater and marine nearshore rearing habitats are limited and have been degraded from historical conditions across the watershed. Population growth rate from EDT model and NOAA = ~1 or less. Co-manager estimate is 0.53 returns per spawner (2004-07). Prior to the availability of mass marking data, the NMFS BRT had estimated the growth rate ranges between 0.995 and 1.077. However, a large contribution of hatchery strays (unmarked prior to 2002) masks a stream productivity rate as low as 0.06 to only 0.931 (natural origin recruit females per natural origin female) from the 1999-2003 broodyears. Natural productivity from other seeded urbanized areas (e.g., North, Little Bear, Kelsey creeks) is likely extremely low (potentially population sinks). High water temperatures affecting rearing and outmigration in early summer and adult migration in late summer may influence migration and survival and increase pre-spawn mortality. Low summer-fall flows impede adult access to Cottage Lake Creek, and passage above barriers such as beaver dams. Severe lack of pools within the Sammamish River and tributaries for adult holding and juvenile rearing exacerbate thermal effects. Predation on Chinook within Lake Sammamish may be high. One study found that yellow perch, cutthroat, and smallmouth bass consumed Chinook smolts, with perch predation on Chinook higher than previously assumed. Yellow perch utilize littoral areas and are numerous in the lake. The artificially abrupt transition zone from fresh to saltwater and warm to cold water for juveniles and adults at the Ballard Locks likely affects survival, however the degree of any effect is unknown. There have been observations of fish kills observed immediately upstream and downstream of the Locks in 1998 and 2004 (Roger Tabor, Kurt Fresh, WDFW and MIT fish counters, Jenny Newell, UW researcher, others), caused partly by passage problems and potentially also disease, likely exacerbated by high temperatures. There are documented fish kills on the Sammamish River for adult Chinook in 1998 and 1999 likely a result of high temperature in the Ship Canal and Sammamish River (K. Fresh et al, 1999 and R.Tabor, 2002, unpub). Approximately 24 exotic non-native fish species occur in the Lake Washington/Sammamish watershed with associated interactions with Chinook. Fish community changes (increased cutthroat trout, river lamprey, but fewer sculpin, coho) due to hydrologic change from	For Bear-Cottage creek, see Cedar River effect. For Issaquah Creek, harvest has not reduced surplus hatchery escapement to desired levels due in part to terminal area restrictions aimed at protection of Cedar River Chinook.	Also, See Cedar River effect. Hatchery influence may have led to reduced intrinsic productivity in the natural environment via domestication. Pre-spawning mortality was highest in Issaquah Creek (23%) and lowest in Cedar River and may be due to density in Issaquah Creek. In both Bear Creek and the Cedar River, pre-spawning mortality is higher in marked vs. unmarked Chinook, irrespective of spawning site density (Berge et al. 2006). It should be noted that differential prespawn mortality may result from non-genetic causes, e.g., "lost" Issaquah hatchery strays may accumulate more thermal stress or depleted energy stores before reaching their spawning destination. Escapement to Issaquah Creek often exceeds goals for broodstock and habitat seeding. This over-escapement can reduce productivity per spawner in Issaquah creek. Hatchery managers recognize this problem and have begun to control numbers passed upstream. Increasing the proportion of NORs in the broodstock has begun and is expected to improve the fitness of the composite stock. Chinook persistence at a significant or harvestable level without hatchery supplementation in the Sammamish basin is questionable. Integration to accomplish higher pNOB and therefore higher proportion of natural influence should increase fitness for natural production and the fitness of hatchery fish spawning in the wild.

	urbanization may result in decreased community diversity and lower productivity for juvenile salmonids, including Chinook. EDT modeling suggests productivity is reduced at egg incubation, fry colonization and fry migrant life stages in streams as well as in common migratory habitats.		
Certainty of effect	Good agreement on certainty of effect.	Good agreement on certainty of effect.	
Questions/ Risks?	What is the natural productivity of Issaquah Creek? Is there opportunity for increased productivity of the Sammamish population as a result of fixing the intake weir passage problem? What other habitat improvement and restoration opportunities exist to increase the productivity of the population? Will these actions reverse or offset impacts from ongoing land use, climate change, and human population growth in the basin ?	Could selective harvest provide an increased opportunity while maintaining protection for unmarked Chinook?	Is hatchery straying reducing fitness of non-hatchery Chinook (probably naturalized of hatchery-origin) in the Sammamish pop'n? I.e., how do risks from domestication effects compare to benefits from increased abundance from hatchery production, especially across different streams? Decreased production might improve fitness at significant expense to abundance and distribution, especially in Tier II streams. Similarly, introgression between HOR and NORs may decrease the productivity of their offspring that would be identified as NORs. As most NORs are likely the progeny of hatchery parents, and interbreeding has occurred for many generations, what is the likelihood of further decreases in productivity?

Spatial Distribution

Samm Action	Habitat	Harvest	Hatchery
Effect	The spatial structure of the naturally spawning Sammamish population is restricted, mostly as a result of habitat degradation. The Technical Committee hypothesizes that spawning was historically distributed by available suitable habitat area across the larger creeks, such as Bear, Swamp, North, Little Bear and Kelsey creeks. Spatial structure likely expands and contracts with total population abundance. The PSTRT (2001) notes a lack of information regarding historic Chinook use of the Sammamish River tributaries, making this hypothesis difficult to confirm. Based on the spawner capacity analysis developed for NOAA Fisheries by the PSTRT (Ruckelshaus et al. 2006), the Issaquah, Bear/Cottage system and the lower portion of North Creek have a high probability of supporting Chinook spawning (in that order), while Swamp Creek, Little Bear Creek, Kelsey, and the upper portion of North Creek had a moderate probability of supporting spawning. Distribution extends beyond these primary tributaries to other tributaries, such as May, Thornton, McAleer, Evans, Coal, and Juanita creeks and others episodically, perhaps driven currently as a function of higher hatchery returns. The current upper limits of spawning may have been reduced by low fall flows and impaired access in some tributary mouths, and lack of suitable spawning, holding, and rearing habitat. Effects from higher temperatures may influence spatial distribution as adult migration is impaired at the locks and Sammamish River and Lake temperatures may influence behavior to spawn in cooler Sammamish tributaries.	See Cedar. Current harvest practices are not known to skew the spatial distribution, as distribution is not known to vary temporally or be related to size or age of adults both of which could be influenced by harvest. The lack of significant harvest of surplus hatchery produced fish may influence spatial distribution – the more hatchery origin returns to the watershed, the wider the spatial distribution.	HORs on the spawning ground increase the extent of spatial distribution of this population. The hatchery weir and intake structures have reduced the spatial distribution of spawning and rearing Chinook in Issaquah Creek.
Certainty of effect	Moderately high certainty of effect.	Moderately high certainty of effect..	Moderately high certainty of effect.
Questions/ Risks?	Is production from spatially distributed salmon (HOS[2]s or NOR[3]s) contributing to population persistence? Or are these all sink areas for HOSs? How is spatial distribution affected by flows and thermal influences? What role does the amount of flow and size of the channel play in sustaining a naturalized population of Chinook?	What role would selective harvest have on increasing the spatial distribution of NOR spawners in the Sammamish population?	

[2] HOS = Hatchery-origin spawners
[3] NOR = Natural-origin recruits

Diversity

Samm Action	Habitat	Harvest	Hatchery
Effect	Juveniles exhibit two rearing strategies, a fry migrant and smolt (parr) migrant, with most juveniles emigrating as smolts. Opportunity for slough rearing (or other life history strategies) may have been lost. Greater alteration of habitats that produce strong selection such as thermal regimes, loss or isolation of side-channel/off-channel habitats and predation will influence within-population diversity. Early spawning fish are likely less numerous given higher temperatures and low flows and winter scour. Late spawning fish may be less numerous given reduced spring outmigration flows relative to earlier spawning fish. These combined effects lead to compression of spawning timing.	See Cedar. In 1980s and 90s, large mesh gear may have been selective for removal of larger Chinook in the gillnet fisheries. Current mesh sizes in terminal areas for coho and sockeye do not select for larger Chinook.	The Sammamish population almost certainly has been replaced by Green River origin fish so as to obscure any historical origin population, if any existed. The current naturally-spawning population is derived from the introduced hatchery stock, which is both geographically and genetically a closely related stock. A substantial number of hatchery fish have been found on the Bear Cottage spawning grounds (64%-79 %) and more than 90% in Issaquah creek in 2007. Findings from Warheit and Bettles (2005) indicates both Cedar and Bear/Cottage NORs are differentiated from the Issaquah Hatchery, while naturally spawning adults from Issaquah creek were only weakly differentiated. Hatchery origin fish have a more uniform age distribution, with hatchery (marked) returns predominately Age-4. Age-4 marked fish are smaller for both males and females than unmarked adults (2003-2005 data – Berge et al. 2006). The effects of HORs on life history diversity of NORs in the Sammamish basin are unknown. Issaquah hatchery now exclusively uses broodstock returning to Issaquah Creek and no longer uses broodstock from Soos Creek hatchery.
Certainty of effect	Moderately high certainty of effect.	Moderately high certainty of effect.	High certainty.
Questions/ Risks?			

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