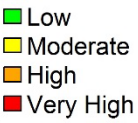
Middle Columbia River spring-run Chinook

Overall vulnerability—High (48% High, 53% Very high)
Biological sensitivity—High (93% High, 0.07% Very high)
Climate exposure—High (52% High, 48% Very high)
Adaptive capacity—Moderate (2)
Data quality—79% of scores ≥ 2

Middle Columbia River spring-run Chinook		Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.3	2.5	
	Juvenile freshwater stage	3.5	2.5	
	Estuary stage	1.5	2.3	
	Marine stage	2.7	2	
	Adult freshwater stage	3.7	3	
	Cumulative life-cycle effects	3.2	2.5	
	Hatchery influence	2.7	2.5	
	Other stressors	3.3	3	
	Population viability	2.4	2.5	
	Ocean acidification sensitivity	1.9	1.8	
	Sensitivity Score	High		
Exposure variables	Stream temperature	3.4	2.3	
	Summer water deficit	3	1.8	
	Flooding	2.4	2	
	Hydrologic regime	3.7	2.5	
	Sea level rise	1.9	2.3	
	Sea surface temperature	3.4	2	
	Ocean acidification exposure	3.8	2.5	
	Upwelling	2.3	1.8	
	Ocean currents	1.8	1.3	
	Exposure Score	High		
Overall Vulnerability Rank		High		



Life History Synopsis

Middle Columbia River spring-run Chinook adults migrate to natal tributaries in April and May. Adults generally range in age from 3 to 5, with 4-year-olds dominating in most years (Myers et al. 1998). Several large tributaries to the Columbia support production of this DPS including the Deschutes, Klickitat, John Day and Yakima Rivers. These tributaries enter the Columbia upstream from mainstem dams numbering from one (Klickitat River) to four (Yakima River). Adults migrate to natal tributaries relatively quickly, and then hold over summer for several weeks prior to spawning. Spawning occurs from late August through late September depending on flow and temperature in specific watersheds. Emergence occurs in early spring, from February to May, with most populations peaking in March, and again depending on watershed-specific temperature and flows.

Middle Columbia River spring-run Chinook exhibits a yearling life history, spending the first summer and winter in fresh water before the juvenile migration. Following a pattern similar to that seen in other Interior Columbia spring runs, juvenile smolts move rapidly through the estuary (Weitkamp et al. 2015). After ocean entry, juveniles swim rapidly northward along the continental shelf (Fisher et al. 2014, Teel et al. 2015). Like other stream-type Chinook, the Middle Columbia River spring-run Chinook DPS is thought to have an oceanic marine distribution, and individuals are rarely caught in coastal fisheries (Healey 1983, Myers et al. 1998, Riddell et al. 2018).

This DPS is not listed under the ESA (Myers et al. 1998), but is identified as a sensitive species by the State of Oregon (ODFW 2016). The DPS includes populations existing under a range of habitat conditions within several major tributaries to the Columbia River (Lindsay et al. 1989, Bare et al. 2014). Populations in the lower elevation reaches of those tributaries are subject to higher temperatures during holding, spawning and juvenile rearing and are also most impacted by degraded habitats. In some cases, impassable dams block access to higher elevation habitats with colder temperatures that could support production under projected future climate change. Extirpated natural production areas in the Upper Deschutes Basin are the focus of ongoing restoration efforts (Lindsay et al. 1989).

Climate Effects on Abundance and Distribution

Across the Middle Columbia River spring-run Chinook DPS, the majority of populations are in watersheds transitioning to rain- vs. snow-driven flow patterns (Ruesch et al. 2012, Dittmer 2013, Clifton et al. 2018). There is considerable variation in flow and temperature regimes within and across drainages used by this DPS. Summer rearing conditions can be limited by temperature and flow in a majority of populations, either overall or in large sections (Hatten et al. 2014). Extant populations in upper reach production areas are generally intact, but declines in habitat quality have resulted in general losses of productive capacity in lower tributary production areas. Most populations are subject to peak summer temperatures during the prolonged prespawn holding phase (Myers et al. 1998, Bare et al. 2014). The presence of tributary dams or irrigation diversions in most drainages may exacerbate exposure to high temperatures.

The ***high*** overall sensitivity rank of this DPS stemmed from the combination of its migration, adult holding and juvenile rearing patterns. Negative effects of higher temperatures during the adult and *juvenile freshwater stages* have been documented (Ruesch et al. 2012, Tattam et al. 2015). Timing of the adult migration puts spawners at risk of exposure to increasing late spring/early summer temperatures (Keefer et al. 2008) through the Columbia River mainstem as well as the mainstems of large tributaries such as the Yakima, John Day, and Deschutes River. In addition, adults hold over the summer in upstream reaches prior to spawning in early fall. High prespawn mortality during this phase has been observed and is believed to be associated with increases in stream temperatures and decreases in pool habitat (Bare et al. 2014). This DPS was ranked ***very high*** for the *adult freshwater stage*.

Juveniles spend a full year in fresh water and experience negative effects on survival from high summer temperatures and low flows (Hatten et al. 2014, Tattam et al. 2015). Sensitivity in the *juvenile freshwater stage* ranked ***high***, and exposure to *hydrologic regime* shift and stream temperature both ranked ***very high***. Because the majority of the population exhibits the yearling life history, loss of this rearing strategy would mean significant loss of a characteristic of this DPS. Vulnerability at multiple life stages increases the risk for c*umulative life-cycle effects*. For example, changes in temperature and flow affect rearing, smolt survival, and migration timing, which in turn may affect early marine survival (Crozier et al. 2008).

The hydrology of most river basins supporting Mid-Columbia Spring Chinook production are classified as transitional between rain-and snow-dominated flow patterns. Climate models project that these basins will shift towards rain-dominated flow regimes with earlier runoff peaks and lower summer baseflows (Dittmer 2013, Clifton et al. 2018), thus exposure to *hydrological regime* shift was ranked ***high*** for this DPS. These shifts would detrimentally affect juvenile rearing and adult prespawn life stages. Stream temperatures in the Mid-Columbia River tributaries used by this DPS for spawning and extended juvenile rearing are also warming rapidly, so exposure to *stream temperature* was scored ***high***.

Mid-Columbia spring-run Chinook exhibit ocean entry and return patterns similar to those of Snake River spring/summer Chinook. Although estimated smolt-to-adult return rates for this DPS are generally higher than those of Snake River conspecifics, they are strongly correlated with estimates for Snake River spring/summer Chinook. Based on these similarities, the Mid-Columbia spring Chinook DPS was also ranked ***high*** for sensitivity in the *marine stage*. Marine survival is lower for this DPS during warm phases of the Pacific Decadal Oscillation, and rising *sea surface temperature* will likely have impacts similar to the warm ocean conditions related to both warm-phase PDO and low survival.

For Mid-Columbia spring Chinook, a longer juvenile freshwater residence period resulted in sensitivity scores that were ***high*** at the *juvenile freshwater stage*. This DPS was scored ***low*** at the estuary stage due to its relatively short residence time in the estuary (Teel et al. 2015, Weitkamp et al. 2015).

Of primary concern in cumulative life-cycle effects is the loss of unique life history types historically enabled by the availability of a diverse set of habitats. Functional losses of downstream rearing habitat due to degraded habitat quality have already reduced or eliminated historical life history patterns in many populations (Ruesch et al. 2012, Tattam et al. 2015). Cumulative effects of shifts in successive life stages may also reduce survival in subsequent life stages. For example, earlier migration timing at the juvenile freshwater stage may mean fish are smaller at ocean entry, which in turn reduces survival at the early ocean stage. Thus, sensitivity of this DPS was considered ***high*** for cumulative life-cycle effects.

Extrinsic Factors

Freshwater habitat loss and reduction in spatial structure are important concerns for this DPS compared with others in this assessment. While some tributary spawning and rearing areas are in relatively pristine wilderness habitats, most production areas for this DPS are highly impacted by anthropogenic factors associated with agriculture, roads and land development. Smallmouth bass, an introduced warm-water species and predator on young-of-the-year Chinook, are present in several tributaries that support juvenile rearing. Increasing temperatures are allowing bass to extend further upstream, potentially overlapping juvenile spring Chinook rearing areas (Lawrence et al. 2012). Tributaries that support spawning and rearing are located upstream from between one and four dams on the mainstem Columbia River. As a result passage impacts in warm years can potentially vary in magnitude across populations. Therefore, sensitivity to *other stressors* was ranked ***high***.

Adaptive Capacity

Overall the Middle-Columbia River spring-run Chinook salmon DPS was ranked ***moderate*** in adaptive capacity. Some populations within this DPS may have sufficient adaptive capacity to reduce juvenile freshwater residence time, either by migrating earlier in the year or by increasing the proportion of subyearling migrants. Adults may have the potential to shift to an earlier migration timing to avoid high stream temperatures in the migration corridor. However, early migrant adults in this DPS will still need to hold for extended periods until temperatures cool in the fall, and this will increase exposure to high *stream temperature*. Energetic costs during the holding period might limit adaptive capacity in the adult stage.

Literature Cited

Bare, C. M., J. L. Latshaw, I. A. Tattam, J. R. Ruzycki, and R. W. Carmichael. 2014. Chinook Salmon productivity and escapement monitoring in the John Day River basin. Oregon Department of Fish and Wildlife Tech. Rept OWEB Contr. 212-909.

Clifton, C. C., K. T. Dary, C. H. Luce, G. E. Grant, M. Safeeq, J. E. Halofsky, and B. P. Staub. 2018. Effects of climate change on hydrology and water resources in the Blue Mountains, Oregon, USA. Clim Serv **10**:9-19.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evol Appl **1**:252-270.

Dittmer, K. 2013. Changing streamflow on Columbia basin tribal lands—climate change and salmon. Clim Change **120**:627–641.

Fisher, J. P., L. A. Weitkamp, D. J. Teel, S. A. Hinton, J. A. Orsi, E. V. Farley, J. F. T. Morris, M. E. Thiess, R. M. Sweeting, and M. Trudel. 2014. Early ocean dispersal patterns of Columbia River Chinook and coho salmon. Trans Am Fish Soc **143**:252-272.

Hatten, J. R., T. R. Batt, P. J. Connolly, and A. W. Maule. 2014. Modeling effects of climate change on Yakima River salmonid habitats. Climatic Change **124**:427-439.

Healey, M. C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type Chinook salmon, *Oncorhynchus tshawytscha*. Can Field-Nat **97**.

Keefer, M. L., C. A. Peery, and C. C. Caudill. 2008. Migration timing of Columbia River spring Chinook salmon: effects of temperature, river discharge, and ocean environment. Trans Am Fish Soc **137**:1120-1133.

Lawrence, D. J., J. D. Olden, and C. E. Torgensen. 2012. Spatiotemporal patterns and habitat associations of smallmouth bass (*Micropterus dolomieu*) invading salmon-rearing habitat. Freshwat Biol **57**:1929-1946.

Lindsay, R. B., B. C. Jonasson, S. R.K., and B. C. Cates. 1989. Spring Chinook Salmon in the Deschutes River, Oregon. Oregon Department of Fish and Wildlife.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, S. W. Grant, W. F. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dep Commerce NOAA Tech Memo NMFS NWFSC 35, Seattle, WA.

ODFW, Oregon Department of Fish and Wildlife. 2016 Sensitive Species List Oregon Department of Fish and Wildlife. Avaialble from www.dfw.state.or.us/wildlife/diversity/species/docs/2017_Sensitive_Species_List.pdf.

Riddell, B. E., R. D. Brodeur, Alexander V. Bugaev , P. Moran, J. s. M. Murphy, J. h. A. Orsi, M. Trudel, L. A. Weitkamp, B. K. Wells, and A. C. Wertheimer. 2018. The ocean ecology of Chinook salmon Pages 555-696 *in* R. J. Beamish, editor. The ocean ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, MD.

Ruesch, A. A., C. E. Torgersen, J. J. Lawler, J. D. Olden, E. E. Peterson, C. J. Volk, and D. J. Lawrence. 2012. Projected climate-induced habitat loss for salmonids in the John Day River network, Oregon, U.S.A. Trans Am Fish Soc **144**:1237-1248.

Tattam, I. A., J. R. Ruzycki, J. L. McCormick, and R. W. Carmichael. 2015. Length and Condition of Wild Chinook Salmon Smolts Influence Age at Maturity. Trans Am Fish Soc **145**:1237-1248.

Teel, D. J., B. J. Burke, D. R. Kuligowski, C. A. Morgan, and D. M. Van Doornik. 2015. Genetic identification of Chinook salmon: Stock-specific distributions of juveniles along the Washington and Oregon Coasts. Mar Coast Fish **7**:274-300.

Weitkamp, L. A., D. J. Teel, M. Liermann, S. A. Hinton, D. M. Van Doornik, and P. J. Bentley. 2015. Stock-specific size and timing at ocean entry of Columbia River juvenile Chinook salmon and steelhead: Implications for early ocean growth. Mar Coast Fish **7**:370-392.