Memorandum

Date:	May 15, 2013
To:	John Arterburn, Colville Confederated Tribes
Cc:	Casey Baldwin, CCT; Mike Tonseth & Ryan Mann, WDFW; Russ Langshaw, Grant County PUD; Tracy Hillman, BioAnalysts
From:	Eric Doyle and Greg Blair, ICF International
Subject:	**Final EDT Okanogan Summer/Fall-run Chinook Salmon Life History Model**

Introduction

ICF International is working with the Confederated Tribes of the Colville Indian Reservation (CCT) to update the Ecosystem Diagnosis and Treatment (EDT) model for summer-fall Chinook salmon in the Okanogan River subbasin. The purpose of this effort is to integrate EDT with the Okanogan Basin Monitoring and Evaluation Program's (OBMEP) long-term habitat status and trends monitoring efforts in this subbasin. This integration will provide the ability to express observed habitat trends in terms of the change in habitat potential for Chinook salmon.

A core component of EDT model development is the definition of life history models that are representative of the full range of life history characteristics exhibited by Okanogan summer/fall-run Chinook population. The life history model will be used to develop EDT model populations that are representative of the life history diversity of this population, current and potential spawning habitats, and juvenile and adult movement patterns within the Okanogan subbasin and Columbia River mainstem.

ICF and CCT convened a workshop with regional fisheries experts on February 8th, 2013. The purpose of this workshop was to obtain sufficient data and information necessary to update the existing EDT Okanogan summer/fall Chinook model population. These experts included:

- John Arterburn – CCT, OBMEP manager
- Casey Baldwin – CCT, Anadromous Fish Program manager
- Mike Tonseth – Washington Department of Fish and Wildlife (WDFW)
- Ryan Mann – WDFW
- Russell Langshaw – Grant County Public Utilities District

- Tracy Hillman – BioAnalysts, Inc.

These individuals, referred to hereafter as the Workgroup, shared available data and knowledge about the Okanogan summer/fall-run Chinook population, and provided input on key components to include in the life history model.

This information obtained from the workgroup was used to develop a proposed set of life history parameters to be used to model this population in EDT. These parameters were described in a draft life history model technical memorandum presented for review and comment by the Workgroup and CCT staff and contractors at the Chief Joseph Hatchery Program (CJHP) Annual Project Review meeting on March 5-6, 2013. This final technical memorandum reflects the review comments provided by these individuals.

Behavioral Forms Identified by the Workgroup

The consensus of the Workgroup is that the extant Okanogan summer/fall-run Chinook population is composed of two primary adult behavioral forms, a summer-run component divided into two subtypes, and a fall-run component, defined as follows:

- Summer-run Chinook - Direct Adult Migrant: Summer-run migrants that enter the Okanogan River immediately; migrate directly to summer holding habitats in the Similkameen River and possibly other mainstem habitats before dispersing to spawning areas.
- Summer-run Chinook – Delayed Adult Migrant: Summer-run migrants that hold in the Columbia River mainstem near the mouth of the Okanogan (i.e. the Wells Pool) for several weeks to months before migrating to upriver holding habitats in the Similkameen River and possibly other mainstem habitats and reside for several weeks, and then disperse to spawning areas.
- Fall-run Chinook: Late-summer through fall adult migrants that migrate directly to spawning habitats, exhibiting limited holding behavior.

These component life history forms provide a basis for developing the EDT life history model for Okanogan Chinook. They are generally consistent with adult migratory patterns observed by WDFW radiotelemetry studies of Okanogan Chinook migration and spawning behavior (Mann 2013). However, it is important to remember that the intent of the EDT model is to characterize habitat potential for a species of interest across a broad range of life history expression. Limiting the model to a narrow range of life history characteristics defined by existing degraded conditions will likewise limit our ability to identify the factors having the greatest effect on life history diversity. Therefore our knowledge of the existing population serves as a starting point for developing a model population, rather than a literal template. The EDT life history model proposed herein follows this guidance.

I suggest including a section here to summarize the spawning ground survey data we reviewed at the meeting. In particular spawn timing was later in the lower reaches (downstream of ???)

The two proposed summer-run behavioral forms, a direct migrant and a delayed migrant, are proposed to represent the population response to thermal barrier conditions that form in the lower Okanogan River during the warmest months of the summer. The consensus of the workgroup is that Chinook delay entry into the Okanogan River when daily average water temperatures exceed 21°C. WDFW radiotelemetry studies generally confirm this conclusion (Mann 2013). Temperatures exceeding this threshold typically occur from mid-July through late-August. Individuals arriving at the mouth of the Okanogan before the barrier forms are able to migrate directly to summer holding habitats in the Similkameen River and possibly elsewhere on the Okanogan/Okanagan mainstem. Those individuals that arrive after the barrier is in place hold in the Wells Pool and wait for temperatures to drop before migrating to holding habitats. Once temperatures drop below 21C ° both the holding adults and newly arrived migrants are able to migrate directly to mainstem holding and spawning habitats. The fall-run behavioral form represents the late-migrant ocean-type component of the Chinook run. This component includes those individuals that pass the Wells Dam in late-summer after the thermal barrier has subsided and migrate directly to upstream spawning habitats where they hold for a shorter overall period of time prior to spawning in comparison to the summer-run adult behavioral forms. The U.S. subpopulation demonstrates differential spawning habitat selection, with direct migrant summer-runs spawning higher in the subbasin near the Similkameen confluence, delayed migrants spawning farther downstream, and the fall-run component spawning the farthest downstream between Mallot and Riverside. Canadian subpopulation spawning habitat selection is not well understood, but is assumed to be similar for the purpose of EDT modeling.

These three proposed population components provide sufficient flexibility to characterize Chinook population performance in EDT under current and historical conditions without generating a large number of unrealistic trajectories that could skew estimates of habitat potential. This will include the creation of trajectories that enter the lower Okanogan River during the typical annual thermal barrier period.These population components will be further refined to better represent juvenile migratory behavior. The Workgroup concurred that the majority (>95%) of the summer-run population and likely 100% of the fall-run population exhibit a spring-early summer juvenile outmigration life history, initiating outmigration as subyearlings. However, evidence of rearing behavior derived from adult scale samples indicates that a percentage of subyearling juveniles exhibit a "reservoir type" life history. These individuals halt their seaward migration in the Wells Pool, overwinter in the reservoir, and leave for the ocean the following spring.

The Workgroup hypothesized that late-migrating juveniles experience sufficient thermal stress that by the time they arrive in the Wells Pool they are unable to continue their migration and revert to resident rearing.[1] The small percentage of individuals that survive to the reservoir find suitable temperatures and food resources, providing the opportunity to grow and outmigrate the following spring as a yearling. . The Workgroup concurred that approximately 89% of the population are subyearling migrants, 10% are reservoir-type yearling migrants, and 1% are yearling migrants. We propose a distribution of 85%, 10%, and 5%, for EDT modeling purposes, respectively, in order to ensure that the model generates a sufficient number of trajectories to adequately characgterize the performance of the yearling type migrants.

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[1] Hypothesis presented by Mike Tonseth, WDFW, on the basis of estimated smolt thermal exposure and available literature describing the relationship between temperature exposure during migration and residualization.

Limited data were available to characterize the Canadian component of the population. The available data from video monitoring at Zosel Dam indicates the majority of extant Canadian Chinook are fall-run fish. A small number of earlier migrating (summer-run) adults are observed periodically, but temperature and dissolved oxygen conditions in the south basin of Osoyoos Lake are likely limiting to survival for this component of the population. The EDT model will generate trajectories that migrate during this period in order to appropriately characterize historical conditions. Direct observations of spawning Chinook are limited in the upper basin. However, the system appears to maintain a sustained abundance of late spawning chinook, suggesting that those individuals are experiencing conditions suitable for incubation and juvenile rearing.

Other Information Sources

In addition to the behavioral forms identified by the work group, additional information on the biological characteristics Okanogan summer/fall-run Chinook salmon is needed to fully develop the EDT model population. These characteristics include the age composition of the population components, observed population sex ratios and fecundity, ocean and mainstem survival rates, and the existing harvest management regime. These parameters will be used to refine the survival conditions experienced by the model populations in EDT.

Male/Female Ratio

Sex ratios of natural origin (NOR) spawners were derived from Chinook salmon spawning ground survey records for the Okanogan and Similkameen Rivers for 2006 through 2010 (Hillman et al. 2008, 2009, 2010, 2011; Miller 2007). Observed male/female ratios are shown in Table 1. The fecundity value for Okanogan summer/fall Chinook is 5,000 eggs per female, which is the management assumption value used in the Hatchery Genetic Management Plan for this population (WDFW 2005).

Table 1. Observed male to female ratio of NOR summer/fall-run Chinook salmon spawning in the Okanogan and Similkameen Rivers, 2006-2010.

Year	Okanogan River				Similkameen River			
	Male	Female	M/F Ratio	Fish/ Redd	Male	Female	M/F Ratio	Fish/ Redd
2010	198	203	0.98	1.98	119	292	0.41	1.41
2009	228	361	0.63	1.63	228	361	0.63	1.63
2008	387	134	2.89	3.89	218	208	1.05	2.05
2007	319	387	0.82	1.82	107	373	0.29	1.29
2006	146	273	0.53	1.53	221	300	0.74	1.74
Geometric Mean	**241**	**253**	**0.95**	**2.04**	**169**	**301**	**0.56**	**1.60**

Ocean and Mainstem Survival

Ocean and mainstem survival rates are a function of the smolt to adult return (SAR) rates from the upper Columbia River to Bonneville Dam and annual harvest rates. Observed SAR values compiled for upper Columbia Chinook salmon by the Fish Passage Center (Tuomikoski et al. 2012) are shown in Table 2. The Rocky Reach to Bonneville Dam SAR values are specific to stocks originating above Rocky Reach Dam (i.e. Entiat, Methow and Okanogan River Chinook), while the McNary to Bonneville SARs are specific to Wenatchee River origin Chinook but provide additional perspective on year-to-year variation in SAR rates. The Chief Joseph Hatchery program applies a consistent set of assumptions about mainstem and ocean survival rates (Lars Mobrand, personal communication, 2013), current assumptions are shown in Table 3.

Table 2. Observed NOR upper Columbia Chinook salmon smolt to adult return rate (SAR) from McNary Dam (MCN) to Bonneville Dam and from Rocky Reach Dam to Bonneville Dam (Tuomikoski et al. 2012).

Year	McNary to Bonneville SAR (%)		Rocky Reach to Bonneville SAR (%)	
	No Jacks	With Jacks	No Jacks	With Jacks
2010	1.31	1.44	0.80	0.88
2009	2.22	2.4	--	--
2008	2.94	3.26	1.55	1.72
2007	0.75	0.75	--	--
2006	0.43	0.54	--	--
Geometric Mean	**1.22**	**1.35**	**1.11**	**1.23**

Table 3. Out-of-subbasin survival assumptions used by the Chief Joseph Hatchery program.

Assumption Category	Metric	Value
Out of subbasin survival, non-harvest	Juvenile migration survival (Okanogan to Bonneville)	27%
	Ocean survival	2.5%
	Adult mainstem survival (Bonneville to Okanogan)	83%

Mainstem Harvest

The United States v. Oregon Management Agreement for 2008 to 2017 defines the current harvest regime for upper Columbia Chinook salmon. Harvest rates vary depending on total escapement, location, and tribal or non-tribal fishery objectives. The rates are set as a proportion of a spawner escapement goal of 29,000 for the Wenatchee, Entiat, Methow and Okanogan River populations (as measured at Bonneville Dam), with the harvest rate calculated against both natural origin and hatchery origin adults. Tribal and non-tribal fisheries each have rights to 50% of the harvest allocation, with tribal fisheries retaining subsistence and cultural harvest privelidges when escapement falls below the minimum goal. The corresponding non-tribal harvest regime is summarized in Table 4. The All "H" Analysis (AHA) used in the Chief Joseph Hatchery EIS included harvest assumptions for Okanogan River summer/fall-run Chinook salmon. Those assumptions are shown in Table 5. The natural origin harvest rates will be used for EDT modeling purposes.

These assumptions do not account for the likelihood of differential harvest rates between population components. Specifically, the delayed migrant summer-run component of the population holds in the Wells Pool for an extended period of time, and may therefore experience greater exposure to recreational and tribal fisheries effort in the Wells Pool. This implies that different harvest rates should be considered for these two population components in the EDT model. We were not able to identify any information that would support definition of differential harvest rates. Therefore we propose uniform application of the harvest rates used in the AHA model management for consistency.

Table 4. Columbia River harvest regime for upper Columbia summer-run Chinook from U.S. v. Oregon 2008 to 2017.

Run Size at Bonneville	Allowable Treaty Harvest	Allowed Non-Treaty Harvest
<5,000	5%	<100
5,000-16,000	5%	<200
16,000-29,000	10%	5%
29,000-32,000	10%	5-6%
32,000-36,000 (125% of 29,000 escapement goal)	10%	7%
36,500-50,000	50% of total harvestable[1]	50% of total harvestable[1]
>50,000	50% of 75% of margin above 50,000 plus 10,500[2]	50% of 75% of margin above 50,000 plus 10,500[2]

[1] Harvestable fish is defined as run size minus 29,000 for run sizes of 36,250 to 50,000
[2] Total number of harvestable fish above run size of 50,000 = 0.75*(runsize-50,000)+21,000

Table 5. Harvest rate assumptions used in the Chief Joseph Hatchery All-H Fish Management model.

Population Component	Harvest Area	Harvest Rate
Hatchery Origin	Ocean	43%
	Below Bonneville Mainstem	5%
	Zone 6 Mainstem	10%
	Terminal (above Wells)	30%
	Total Exploitation Rate	***65.9%***
Natural Origin	Ocean	43%
	Below Bonneville Mainstem	5%
	Zone 6 Mainstem	10%
	Above McNary Mainstem	27%
	Total Exploitation Rate	***64%***

Proposed EDT Population Components

The proposed EDT life history model for Okanogan summer/fall-run Chinook consists of three distinct adult migrant behavioral forms, further subdivided by juvenile rearing behavior:

- Summer-run, direct migrant: Arrive at mouth of Okanogan prior to the onset of the thermal barrier and migrate directly to summer holding habitats in the subbasin
- Summer-run, delayed migrant: Arrive at mouth of Okanogan after the onset of the thermal barrier and hold in the Wells Pool for an extended period before migrating to upriver holding and spawning habitats

- Fall-run, ocean-type direct migrant: Arrive in early fall after the thermal barrier has subsided and migrate directly to upriver spawning habitats

The Workgroup defined the three juvenile rearing behavioral forms as follows:

- Ocean-type: Migrate to sea as subyearlings
- Reservoir-type: Ocean-type juveniles that initiate seward migrant and then stop upon reaching reservoir habitats (i.e. the Wells Pool) and reinitiating seaward migrant the following spring as yearlings
- Stream-type: Rear in the Okanogan system for their first year and then migrate to sea as yearlings in their second spring

The three adult population components are further subdivided by these juvenile rearing behavioral forms as described in the following sections. Specific EDT life history parameters for each of the 5 life history model subpopulation types are provided in Attachment A.

Summer-Run, Ocean-Type Direct Migrant

The summer-run direct migrant population component includes adult Chinook that arrive at the mouth of the Okanogan and migrate directly to upriver holding habitats. These individuals remain in these holding habitats throughout the summer and then disperse to spawning habitats in the fall.

Adult Terminal Migration

Adult Migration – Columbia River Entry to Okanogan/Okanagan Mainstem

- Period:[2] May 20 to July 31 (Columbia River entry)[3]
- Period (Wells Dam): June 20 – September 15th
- Duration:[4] Defined by migration speed and initiation of adult holding
- Migration speed:[5] 20 to 60 km/day upstream from ocean to Okanogan river mouth (16- to 48-day travel time, 845 km)
- Location:[6] Adult holding initiation reaches (see below)

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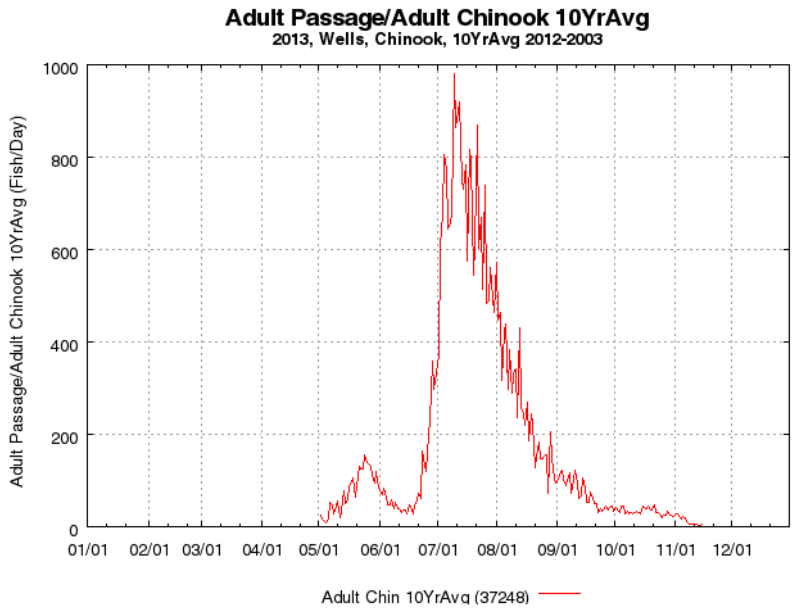
2 The time period over which the life history stage initiates (e.g. lower Columbia River run timing)

3 Initiation date based on extrapolation of migration speed against observed passage at Wells Dam.

4 The duration of the life history stage from beginning to end in days

5 The range of movement speeds exhibited during the life history stage expressed in kilometers per day (km/day) (including both upstream and downstream movement)

6 A specific location occupied by a life history stage or an identified point for initiation of life stage dispersal



DART Data Citation

Columbia River DART, Columbia Basin Research, University of Washington. (2013). Available from http://www.cbr.washington.edu/dart/query/adult_graph_text

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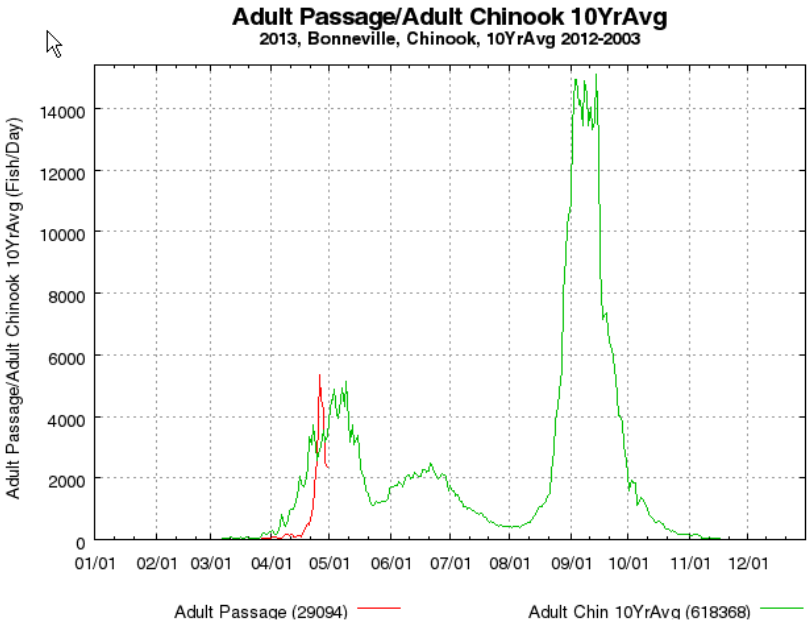
01 May 2013 16:35:50 PDT. Columbia River DART (Data Access in Real Time) www.cbr.washington.edu/dart.



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Columbia River DART, Columbia Basin Research, University of Washington. (2013). Available from http://www.cbr.washington.edu/dart/query/adult_graph_text

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01 May 2013 16:42:58 PDT. Columbia River DART (Data Access in Real Time) www.cbr.washington.edu/dart.

Adult Holding – Okanogan/Similkameen and Okanagan Mainstem Habitats

- Period Mouth Okanogan: June 15 to July 17
- Period (Okanogan): June 15 to September 30
- Location (U.S.): Start dispersal at Okanogan 16
- Location (Canada): Start dispersal at Okanagan 36
- Duration: 73 to 100 days
- Dispersal speed (U.S.): 0 to 2 km/day upstream from dispersal reach

Spawning Migration – Mainstem Holding to Spawning Habitats

- Period: Initiation defined by end of adult holding and/or modeled spawn date
- Location: From final holding location to spawning reach
- Duration: From end of holding to spawn initiation
- Dispersal speed: 20 to 60 km/day downstream to spawning reach

Spawning

Spawning Reaches

U.S. Component

- All mainstem reaches in the following Diagnostic Units (DUs): Okanogan 04, Okanogan 05, Okanogan 06, Okanogan 07, Similkameen Lower, Similkameen Middle, Similkameen Upper

Canadian Component

- All non-lake mainstem reaches in the following DUs: Okanagan River 08; Okanagan River 09; Okanagan River 010; Okanagan River 011; Okanagan River 012

Spawn Timing

- Period: September 25 to October 30
- Duration: 7 days (based on EDT benchmark)

Incubation

- Period: Defined by end of spawning
- Duration: 180 to 190 days (25.7 to 27.1 weeks) based on 1,500 Fahrenheit thermal unit incubation period and average Okanogan mainstem temperatures during incubation (EDT benchmark is 175 days/25 weeks)

Juvenile Residence and Behavior

Fry Dispersal

- Period: Defined by end of trajectory incubation (period and duration)
- Duration: 12 to 17 days based on EDT benchmark duration of 14 days
- Migration speed: 0 to 0.5 km/day

Ocean Migration

- Period: April 22 to August 5 (based on Rotary Screw Trap observations at Highway 20 Bridge in Okanogan [Miller et al. 2012])
- Duration: Determined by migration speed to estuary
- Migration speed: Based on calculated first and last swim up (4/7 to 5/14) to first and last RST detection (4/22 to 8/5)
    - Okanogan Mainstem: 1 to 7 km/day.
    - Columbia River: 17 to 33 km/day, based on distance-weighted average of observed and predicted mainstem travel times (Tuomikoski et al. 2012; Zabel et al. 2008).
- Age structure: Based on adult scale samples the majority (~89%) of surviving adults emigrated as subyearling (ocean-type) migrants; 10% migrated as reservoir-type migrant; and age-1 (stream-type) migrants are a minimal component of population (~1%). Stream-type life history assumed to have been a larger component of historical population for the purpose of life history model construction. Proposed EDT parameters:
    - Subyearling (age-0) ocean-type migrants are 85% of population component
    - Yearling (age-1) reservoir-type migrants are 10% of population component
    - Yearling (age-1) stream-type migrants are 5% of population component

Ocean-type Age-0 Wells Pool Resident Rearing (Summer)

This life history stage applies to portion of population that rears to age-1 in Wells Pool. Wells Pool summer and overwintering component is assumed to be 5% of ocean-type migrant smolts.

- Period: July 15 to August 5
- Duration: 90 to 110 days
- Habitats: Wells Pool
- Dispersal speed: 0 to 0.2 km/day[10]

[10] Winter dispersal speed is intended to represent fall redistribution, allowing the model to distribute trajectories within the model habitat environment to ensure a representative sampling of all potential rearing reaches.

Ocean-type Age-0/1 Wells Pool Overwintering

(This life history stage applies to portion of population that rears to age-1 in Wells Pool.)

- Period: October 15 to November 15
- Duration: 175 to 190 days
- Habitats: Okanogan 1 (Wells Pool)
- Dispersal speed: 0 to 0.2 km/day (resident with limited movement)

Stream-type Age-0 Resident (spring/summer)

- Period: April 21 to May 14
- Duration: 155 to 210 days
- Location: Defined by dispersal speed
- Dispersal speed: 0 to 0.5 km/day (resident with limited movement)

Stream-type Age-0/1 – Inactive Resident (Fall/Winter)

- Period: October 15 to November 15
- Duration: 175 to 190 days
- Habitats: Defined by dispersal speed
- Dispersal speed: 0 to 0.2 km/day (resident with limited movement)

Estuarine Residence

- When do Okanogan Chinook outmigrants enter the Columbia River estuary?
- How long do they rear in the estuarine environment (including the Columbia plume front)?

Ocean Residence

- Marine age distribution (% of population):
  - 2-year: 1%
  - 3-year: 10%
  - 4-year: 53%
  - 5-year: 35%
  - 6-year: 1%

Summer-Run, Delayed Migrant

The summer-run delayed migrant population component includes adult Chinook that arrive at the mouth of the Okanogan and hold in the Wells Pool for an extended period prior to migrating to upriver holding habitats. These individuals then remain in upriver holding habitats for an additional

period and disperse to spawning habitats in the fall. This population component is intended to model mainstem Columbia holding behavior in response to mid-summer thermal barrier conditions in the mainstem Okanogan River.

With the exception of the adult terminal migration and holding behavior, all life stage parameters and juvenile rearing behaviors are identical to those described for the direct migrant form described above. The migratory and holding parameters specific to this behavioral form are described below.

Adult Terminal Migration

Adult Migration – Columbia River Entry to Okanogan/Okanagan Mainstem

- Timing: July 1 to August 15 (Columbia River entry)
- Migration speed: 20 to 60 km/day upstream from river mouth (14- to 42-day travel time)
- Destination: Wells Pool holding habitat

Adult Holding – Wells Pool

- Location: Okanogan 1 (Wells Pool Inundated)
- Timing: July 15 to September 26
- Duration: 30 to 48 days
- Dispersal speed: 0 to 0.1 km/day (full dispersal throughout 4.9 km length of Okanogan 1)

Adult Migration – Wells Pool to Okanogan/Okanagan Mainstem

- Timing: August 15 to September 29 (Okanogan River entry)
- Migration speed: 20 to 60 km/day upstream from river mouth (2- to 6-day travel time)
- Destination: Adult holding initiation reaches (see below)

Adult Holding – Okanogan/Okanagan Mainstem Habitats

- Timing: August 17 to October 1
- Destination (U.S.): Start dispersal at Okanogan 16
- Destination (Canada): Start dispersal at Okanagan 36
- Duration: 3 to 43 days
- Dispersal speed (U.S.): 0 to 2 km/day upstream from holding initiation reach

Spawning Migration – Mainstem Holding to Spawning Habitats

- Location: From final holding location to spawning reach
- Timing: From end of holding to spawn initiation
- Dispersal speed: 20 to 60 km/day downstream to spawning reach

All Other Life Stages

All other life stages of the Summer-run, Delayed Migrant life history form are identical to those described for the Summer-run, Direct Migrant form.

Fall-Run, Direct Migrant

The fall-run, direct migrant Chinook behavioral form arrives at the mouth of the Okanogan in early- to late-fall overlapping the end of the thermal barrier condition. This form holds in the Wells Pool for a variable period of time and then migrates directly to upstream spawning habitats.

Adult Terminal Migration

Adult Migration – Columbia River Entry to Okanogan/Okanagan Mainstem

- Timing: August 1 to September 5 (Columbia River entry)
- Timing Wells Dam:September 1 to October 31??
- Duration: 14 to 42 days
- Migration speed: 20 to 60 km/day upstream from river mouth
- Destination: Wells Pool holding habitat

Adult Holding – Wells Pool

- Location: Okanogan 1 (Wells Pool Inundated)
- Period: September 1 to October 31
- Duration: 1 to 92 days
- Dispersal speed: 0 to 0.04 km/day (full dispersal throughout 4.9 km length of Okanogan 1)

Spawning Migration – Wells Pool to Okanogan/Okanagan Mainstem

- Period: October 18 to November 15 (Okanogan River entry)
- Migration speed: 20 to 60 km/day upstream from river mouth (<1- to 12-day travel time depending on destination in subbasin)
- Duration: Determined by travel time to original trajectory spawning reach

Spawning

Spawning Reaches

U.S. Component

- All mainstem reaches in the following Diagnostic Units (DUs): Okanogan 01, Okanogan 02, and Okanogan 03

Canadian Component

- All non-lake mainstem reaches in the following DUs: Okanagan River 08; Okanagan River 09; Okanagan River 010; Okanagan River 011; Okanagan River 012

Spawn Timing

- Period: October 15 to November 20
- Duration: 7 days (based on EDT benchmark)

Incubation

- Period: Defined by end of spawning
- Duration: 180 to 190 days (25.7 to 27.1 weeks) based on 1,500 Fahrenheit thermal unit incubation period and average Okanogan mainstem temperatures during incubation (EDT benchmark is 175 days/25 weeks)

All Other Life Stages

All other life stages of the Summer-run, Delayed Migrant life history form are identical to those described for the Summer-run, Direct Migrant form. With the following exceptions:

- All fall-run Chinook are considered ocean-type, no juvenile overwintering in Okanogan mainstem with the following distribution of smolting behavior:
    - Subyearling (age-0) ocean-type migrants are 90% of population component
    - Yearling (age-1) reservoir-type migrants are 10% of population component
- Smolt migration speed: 0.5 to 3 km/day (speed differential from upriver spawning forms necessary to distribute juveniles in wells pool for summer rearing)

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Attachment A – Proposed EDT Life History Model Parameters for Okanogan Summer/Fall-Run Chinook

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Okanogan Summer-Fall Chinook Subpopulation #1: Summer-Run, Ocean-Type Direct Migrant

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning	See table note	First wk: Sep 15 Last wk: Oct 30	Min: 0 Max: 7	n/a	n/a	n/a	Based on spawning ground surveys, other observations
Incubation to Emergence	Same as spawning	End of trajectory spawning	Min: 180 Max: 190	n/a	n/a	n/a	Based on average temperatures during incubation period and 1,500 °F thermal unit incubation (EDT benchmark is 175 days)
Fry Colonization	Defined by fry dispersal speed and obstructions	First wk: April 1 Last wk: May 15	Min: 12 Max: 17	n/a	Min: 0 Max: 0.5	n/a	Estimated duration 14-days based on EDT benchmark.
Age-0 transient rearing	Okanogan to Wells Pool pre-smolt	First wk: Apr 22 Last wk: Aug 5	Min: 1 Max: 125	n/a	Min: 1 Max: 7	n/a	Based on duration between calculated first and last swim-up and first and last RST detection.
Age-0 migrant (smolting)	Wells Pool to ocean	First wk: Apr 13 Last wk: Aug 15	Min: 15 Max: 38	90% of sub-population	Min: 17 Max: 33	n/a	Smolt initiation based on CCT observations or literature.

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Age-0/1 Rearing (fall/winter)	Wells Pool Inundated (WinReach Okanogan 1)	First wk: July 15 Last wk: Aug 15	Min: 230 Max: 290	10% of sub-population	Min: 0 Max: 0.1	n/a	Juvenile active and inactive rearing in Wells Pool w/smolting the following spring. (WinReach Okanogan 1). Classify as active rearing through winter due to favorable conditions.
Age-1 migrant	Okanogan 1 to ocean	First wk: April 1 Last wk: May 1	Min: 13 Max: 25	Same as above	Min: 30 Max: 60	n/a	Smolt initiation based on CCT observations or literature, and smolt counts at Wells Dam.
Pre-Spawn Migrant	Ocean to upriver holding habitat	First wk: May 20 Last wk: Jul 1	Defined by travel speed Min: 16 Max: 48	Age 2: 2% Age3: 10% Age 4: 50% Age 5: 35% Age 6: 3%	Min: -20 Max: -60	n/a	Migration from ocean to Wells Pool (WinReach Okanogan 16)*
Pre-Spawn Holding	DUs: Okanogan 06, Similkameen Lower, Similkameen Middle, Similkameen Upper	First wk: Jun 15 Last wk: Aug 18	Min: 73 Max: 100	n/a	Min: 0 Max: -2	n/a	Pre-spawn holding in Okanogan 06 and Similkameen Lower/Middle DUs
Pre-Spawn Migrant	Migrate to spawning habitats	End of holding	Min: 2 Max: 6	n/a	Min: 20 Max: 60	n/a	Migration from Okanogan/Similkameen holding habitats to spawning reach.

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning Diagnostic Units: U.S. Subpopulation: Okanogan 03, Okanogan 04,Okanogan 05, Okanogan 06, Okanogan 07, Similkameen Lower, Similkameen Middle, Similkameen Upper Canadian Subpopulation: All non-lake mainstem reaches in Okanagan River 08, Okanagan River 09, Okanagan River 010, Okanagan River 011, Okanagan River 012 *Note: WinReach is EDT term describing a target destination in the model environment reached at the end of the specified life stage.							

Okanogan Summer-Fall Chinook Subpopulation #2: Summer-Run, Stream-Type Direct Migrant

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning	See table note	First wk: Sep 15 Last wk: Oct 30	Min: 0 Max: 7	n/a	n/a	n/a	Based on spawning ground surveys, other observations
Incubation to Emergence	Same as spawning	End of trajectory spawning	Min: 180 Max: 190	n/a	n/a	n/a	Based on average temperatures during incubation period and 1,500 °F thermal unit incubation (EDT benchmark is 175 days)
Fry Colonization	Defined by fry dispersal speed and obstructions	First wk: April 1 Last wk: May 15	Min: 12 Max: 17	n/a	Min: 0 Max: 0.5	n/a	Estimated duration 14-days based on EDT benchmark.
Age-0 resident rearing	Mainstem Okanogan/Okanagan rearing habitats	First wk: Apr 22 Last wk: June 1	Min: 153 Max: 223	100% of population	Min: 0 Max: 0.5	n/a	Based on duration between calculated first and last swim-up and first and last RST detection.
Age-0/1 Inactive (fall/winter)	Okanogan mainstem habitats	First wk: Nov 1 Last wk: Dec 1	Min: 121 Max: 181	n/a	Min: 0 Max: 0.1	n/a	Juvenile overwintering in mainstem habitats.
Age-1 migrant	Overwintering habitats to ocean	First wk: April 1 Last wk: May 1	Min: 13 Max: 25	n/a	Min: 30 Max: 60	n/a	Smolt initiation based on CCT observations or literature, and smolt counts at Wells Dam.

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Pre-Spawn Migrant	Ocean to upriver holding habitat	First wk: May 20 Last wk: Jul 1	Defined by travel speed Min: 16 Max: 48	Age 2: 2% Age3: 10% Age 4: 50% Age 5: 35% Age 6: 3%	Min: -20 Max: -60	n/a	Migration from ocean to Wells Pool (WinReach Okanogan 16)*
Pre-Spawn Holding	DUs: Okanogan 06, Similkameen Lower, Similkameen Middle, Similkameen Upper	First wk: Jun 15 Last wk: Aug 18	Min: 73 Max: 100	n/a	Min: 0 Max: -2	n/a	Pre-spawn holding in Okanogan 06 and Similkameen Lower/Middle DUs
Pre-Spawn Migrant	Migrate to spawning habitats	End of holding	Min: 2 Max: 6	n/a	Min: 20 Max: 60	n/a	Migration from Okanogan/Similkameen holding habitats to spawning reach.

Spawning Diagnostic Units:

U.S. Subpopulation: Okanogan 03, Okanogan 04,Okanogan 05, Okanogan 06, Okanogan 07, Similkameen Lower, Similkameen Middle, Similkameen Upper

Canadian Subpopulation: All non-lake mainstem reaches in Okanagan River 08, Okanagan River 09, Okanagan River 010, Okanagan River 011, Okanagan River 012

*Note: WinReach is EDT term describing a specific target destination (reach) that must be reached by the end of the specified life stage.

Okanogan Summer-Fall Chinook Subpopulation #3: Summer-Run, Ocean-Type Delayed Migrant

Life History Stage	Diagnostic Unit or Reach	Life Stage Initiation	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning	See table note	First wk: Sep 15 Last wk: Oct 30	Min: 0 Max: 7	n/a	n/a	n/a	Based on spawning ground surveys, other observations
Incubation to Emergence	Same as spawning	End of trajectory spawning	Min: 180 Max: 190	n/a	n/a	n/a	Based on average temperatures during incubation period and 1,500 °F thermal unit incubation (EDT benchmark is 175 days)
Fry Colonization	Defined by fry dispersal speed and obstructions	First wk: April 1 Last wk: May 15	Min: 12 Max: 17	n/a	Min: 0 Max: 0.5	n/a	Estimated duration 14-days based on EDT benchmark.
Age-0 transient rearing	Okanogan to Wells Pool pre-smolt	First wk: Apr 22 Last wk: Aug 5	Min: 1 Max: 125	n/a	Min: 1 Max: 7	n/a	Based on duration between calculated first and last swim-up and first and last RST detection.
Age-0 migrant (smolting)	Wells Pool to ocean	First wk: Apr 13 Last wk: Aug 15	Min: 15 Max: 38	90% of sub-population	Min: 17 Max: 33	n/a	Smolt initiation based on CCT observations or literature.
Age-0/1 Rearing (fall/winter)	Wells Pool Inundated (WinReach Okanogan 1)	First wk: July 15 Last wk: Aug 15	Min: 230 Max: 290	10% of sub-population	Min: 0 Max: 0.1	n/a	Juvenile active and inactive rearing in Wells Pool w/smolting the following spring. (WinReach Okanogan 1). Classify as active rearing through winter due to favorable conditions.

Life History Stage	Diagnostic Unit or Reach	Life Stage Initiation	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Age-1 migrant	Okanogan 1 to ocean	First wk: April 1 Last wk: May 1	Min: 13 Max: 25	Same as above	Min: 30 Max: 60	n/a	Smolt initiation based on CCT observations or literature, and smolt counts at Wells Dam.
Pre-Spawn Migrant	Columbia R. Global Reaches	First wk: Jul 1 Last wk: Aug 15	Min: 14 Max: 42	Age 2: 2% Age3: 10% Age 4: 50% Age 5: 35% Age 6: 3%	Min: -30 Max: -60	n/a	Migration from ocean to Wells Pool (WinReach Okanogan 1)*
Pre-Spawn Holding	Wells Pool Inundated, reach Okanogan 1	First wk: Jul 15 Last wk: Sep 26	Min: 30 Max: 48	n/a	Min: 0 Max: -0.1	n/a	Pre-spawn holding in Wells Pool (WinReach Okanogan 1)*
Pre-Spawn Migrant	Migrate to upriver holding habitats	First wk: Aug 15 Last wk: Sep 29	Min: 2 Max: 6	n/a	Min: -20 Max: -60	n/a	Migration from Wells Pool to Okanogan/Similkameen holding habitats (WinReach Okanogan 16).
Pre-Spawn Holding	Okanogan 06 Similkameen Lower Similkameen Middle	First wk: Aug 17 Last wk: Oct 1	Min: 3 Max: 43	n/a	Min: 0 Max: -2	n/a	Pre-spawn holding in Okanogan 06 and Similkameen Lower/Middle DUs
Pre-Spawn Migrant	Spawning reach	End of holding	Min: 0 Max: 4	n/a	Min: 20 Max: 40	n/a	Migrate from upriver holding to spawning reach

Life History Stage	Diagnostic Unit or Reach	Life Stage Initiation	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning Diagnostic Units: U.S. Subpopulation: Okanogan 03, Okanogan 04,Okanogan 05, Okanogan 06, Okanogan 07, Similkameen Lower, Similkameen Middle, Similkameen Upper Canadian Subpopulation: All non-lake mainstem reaches in Okanagan River 08, Okanagan River 09, Okanagan River 010, Okanagan River 011, Okanagan River 012 *Note: WinReach is EDT term describing a specific target destination (reach) that must be reached by the end of the specified life stage.							

Okanogan Summer-Fall Chinook Subpopulation #4: Summer-Run, Stream-Type Direct Migrant

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning	See table note	First wk: Sep 15 Last wk: Oct 30	Min: 0 Max: 7	n/a	n/a	n/a	Based on spawning ground surveys, other observations
Incubation to Emergence	Same as spawning	End of trajectory spawning	Min: 180 Max: 190	n/a	n/a	n/a	Based on average temperatures during incubation period and 1,500 °F thermal unit incubation (EDT benchmark is 175 days)
Fry Colonization	Defined by fry dispersal speed and obstructions	First wk: April 1 Last wk: May 15	Min: 12 Max: 17	n/a	Min: 0 Max: 0.5	n/a	Estimated duration 14-days based on EDT benchmark.
Age-0 resident rearing	Mainstem Okanogan/Okanagan rearing habitats	First wk: Apr 22 Last wk: June 1	Min: 153 Max: 223	100% of population	Min: 0 Max: 0.5	n/a	Based on duration between calculated first and last swim-up and first and last RST detection.
Age-0/1 Inactive (fall/winter)	Okanogan mainstem habitats	First wk: Nov 1 Last wk: Dec 1	Min: 121 Max: 181	n/a	Min: 0 Max: 0.1	n/a	Juvenile overwintering in mainstem habitats.
Age-1 migrant	Overwintering habitats to ocean	First wk: April 1 Last wk: May 1	Min: 13 Max: 25	n/a	Min: 30 Max: 60	n/a	Smolt initiation based on CCT observations or literature, and smolt counts at Wells Dam.

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Pre-Spawn Migrant	Columbia R. Global Reaches	First wk: Jul 1 Last wk: Aug 15	Min: 14 Max: 42	Age 2: 2% Age3: 10% Age 4: 50% Age 5: 35% Age 6: 3%	Min: -30 Max: -60	n/a	Migration from ocean to Wells Pool (WinReach Okanogan 1)*
Pre-Spawn Holding	Wells Pool Inundated, reach Okanogan 1	First wk: Jul 15 Last wk: Sep 26	Min: 30 Max: 48	n/a	Min: 0 Max: -0.1	n/a	Pre-spawn holding in Wells Pool (WinReach Okanogan 1)*
Pre-Spawn Migrant	Migrate to upriver holding habitats	First wk: Aug 15 Last wk: Sep 29	Min: 2 Max: 6	n/a	Min: -20 Max: -60	n/a	Migration from Wells Pool to Okanogan/Similkameen holding habitats (WinReach Okanogan 16).
Pre-Spawn Holding	Okanogan 06 Similkameen Lower Similkameen Middle	First wk: Aug 17 Last wk: Oct 1	Min: 3 Max: 43	n/a	Min: 0 Max: -2	n/a	Pre-spawn holding in Okanogan 06 and Similkameen Lower/Middle DUs
Pre-Spawn Migrant	Spawning reach	End of holding	Min: 0 Max: 4	n/a	Min: 20 Max: 40	n/a	Migrate from upriver holding to spawning reach

Spawning Diagnostic Units:

U.S. Subpopulation: Okanogan 03, Okanogan 04,Okanogan 05, Okanogan 06, Okanogan 07, Similkameen Lower, Similkameen Middle, Similkameen Upper

Canadian Subpopulation: All non-lake mainstem reaches in Okanagan River 08, Okanagan River 09, Okanagan River 010, Okanagan River 011, Okanagan River 012

*Note: WinReach is EDT term describing a specific target destination (reach) that must be reached by the end of the specified life stage.

Okanogan Summer-Fall Chinook Population #5: Fall-Run, Ocean-Type Direct Migrant

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Spawning	See table note	First wk: Last wk:	Min: Max:	n/a	n/a	n/a	Based on spawning ground surveys, other observations
Incubation to Emergence	Same as spawning	n/a	Min: Max:	n/a	n/a	n/a	Based on average temperature conditions and Chinook incubation degree days
Fry Colonization	Defined by fry dispersal speed and obstructions	First wk: Last wk:	Min: Max:	n/a	Min: Max:	Min: Max:	Estimated duration 14-days based on EDT benchmark.
Age-0 Active Rearing (spring/summer)	Okanogan to Wells Pool pre-smolt	First wk: Last wk:	Min: Max:	n/a	Min: Max:	Min: Max:	Movement b/t incubation and summer rearing habitats
Age-0 migrant	Wells Pool to ocean	First wk: Last wk:	Min: Max:	90% of sub-population	Min: Max:	n/a	Smolt initiation based on CCT observations or literature.
Age-0/1 Inactive Rearing (fall/winter)	Wells Pool Inundated (WinReach Okanogan 1)	First wk: Last wk:	Min: Max:	10% of sub-population	Min: Max:	Min: Max:	Juvenile overwintering in Wells Pool w/smolting the following spring.
Age-1 migrant	Last EDT Model generated overwintering reach	First wk: Last wk:	Min: Max:	Same as above	Min: Max:	n/a	Smolt initiation based on CCT observations or literature, and smolt counts at Wells Dam.

Life History Stage	Diagnostic Unit or Reach	Period	Duration (days)	Age Structure	Travel Speed (km/day)		Description
					Life Stage	Transition	
Pre-Spawn Migrant	Columbia R. Global Reaches	First wk: Aug 1 Last wk: Sep 5	Min: 14 Max: 42	Age 2: 2% Age3: 10% Age 4: 50% Age 5: 35% Age 6: 3%	Min: -20 Max: -60	n/a	Migration from ocean to Wells Pool (WinReach Okanogan 1)*
Pre-Spawn Holding	Begin at terminus of 1st pre-spawn migrant stage	First wk: Aug 15 Last wk: Oct 17	Min: 1 Max: 92	n/a	Min: 0 Max: -0.4	n/a	Pre-spawn holding in Wells Pool (or elsewhere) prior to migration to spawning habitats
Pre-Spawn Migrant	Lower reaches of spawning watersheds (see table note)	First wk: Oct 18 Last wk: Nov 15	Min: 1 Max: 12	n/a	Min: -20 Max: -60	n/a	Migration from holding habitat into spawning tributaries (life stage may occur twice, before and after pre-spawn holding)

Spawning Diagnostic Units:
U.S. Subpopulation: Okanogan 01, Okanogan 02, Okanogan 03
Canadian Subpopulation: All non-lake mainstem reaches in Okanagan River 08; Okanagan River 09; Okanagan River 010; Okanagan River 011; Okanagan River 012

*Note: WinReach is EDT term describing a specific target destination (reach) that must be reached by the end of the specified life stage.