Klickitat River Anadromous Fisheries Master Plan

APPENDICES

Prepared by

The Confederated Tribes and Bands of the Yakama Nation
in cooperation with
Washington Department of Fish and Wildlife

March 2008

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Yakima/Klickitat Fisheries Project 1988-115-35

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APPENDICES

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Appendix A

Proposed Klickitat River Habitat Actions

Table A-1: Proposed Klickitat River Habitat Actions

Action category	Actions	Affected Sites	Time Needed to Implement	Time Needed to Realize Benefits	Implementing Entities	Estimated Cost	Implement -ability (L-M-H)	Comment
Fish passage	Replace culverts	Castile Falls and culverts on several tributary streams	< 3 Years	< 3 Years	Yakama Nation	$100,000 – 500,000	High	Spring Chinook and steelhead are expected to begin re-colonizing spawning and rearing habitat above Castile Falls now that passage has been significantly improved. At least one partial barrier culvert near the mouth of Piscoe Creek, 3 more possible barriers upstream, and a partial barrier near the mouth of McCreedy Creek may be replaced by following BIA timber sale improvement plan. Percent of MSA degraded assumes full passage at Castile Falls.
Research, monitoring, & evaluation	Monitor effectiveness of passage improvements at Castile Falls	Castile Falls	< 3 Years	5 - 10 Years	Yakama Nation	$100,000 – 500,000	High	
Protection	Protect existing habitat from future degradation	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	< 3 Years	3 - 5 Years	Yakama Nation, State land management agency (i.e. WADNR), Private landowner	$2,500,000 – 5,000,000	High	Improved side-channel habitat, pool quality, and quantity will improve rearing habitat and juvenile growth and survival. Numerous private sections in the upper portion of the Diamond Fork watershed were purchased by a developer. WaDNR parcels that are currently in State Lands could be reclassified as Natural Areas.
Channel and floodplain modification	Re-vegetate riparian areas	Chaparral Creek, Coyote Creek, McCreedy Creek, Butte Meadows Creek, Klickitat R. from Castle Falls (RM 65.75) to RM 87.05, upper Diamond Fork	3 - 5 Years	5 - 10 Years	Yakama Nation	$100,000 – 500,000	High	Actions will lead to improved floodplain connectivity, pool quality, gravel sorting and stability, thus increasing available refugia, improving rearing habitat, and juvenile and egg-to-fry survival.

Action category	Actions	Affected Sites	Time Needed to Implement	Time Needed to Realize Benefits	Implementing Entities	Estimated Cost	Implement-ability (L-M-H)	Comment
	Place LWD or other structures to stop headcutting	Chaparral Creek, Coyote Creek, McCreedy Creek, Butte Meadows Creek, Klickitat R. from Castle Falls (RM 65.75) to RM 87.05, upper Diamond Fork	3 - 5 Years	3 - 5 Years	Yakama Nation	\$500,000 – 1,000,000	Moderate	
	Reduce fine sediment introduced from streambank mass wasting	Chaparral Creek, McCreedy Creek, Piscoe, Diamond Fork, Coyote, Butte Meadows, Klickitat R. from Castile Falls (RM 65.75) to RM 87.05	< 3 Years	5 - 10 Years	Yakama Nation	\$100,000 – 500,000	Moderate	Point source delivery of fine sediment from roads; stream bank mass wasting. Actions will decrease run-off/peak flows and sediment introduction, decrease interception and incision of shallow groundwater flows, and restore valley-bottom morphology and potential for channel migration. Spawning and rearing habitat will be improved; egg-to-fry survival will increase.
	Improve channel complexity and connectivity	Klickitat River from RM 70.5 to RM 87.05, Chaparral Creek, Diamond Fork, Piscoe Creek	3 - 5 Years	3 - 5 Years	Yakama Nation	\$100,000 – 500,000	Moderate	Greater impact of reduction in food web on fry colonization in mainstem than in tributaries. Reducing sediment inputs will increase aquatic insect production for food. Carcass analogs may provide a temporary food source for juveniles. Actions will improve primary and secondary productivity by improving substrate conditions.
	Restore floodplain connectivity	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork,	3 - 5 Years	3 - 5 Years	Yakama Nation	\$100,000 – 500,000	Moderate	Hydroconfinement; floodplain roads; historic overgrazing. Potential habitat fragmentation.

Action category	Actions	Affected Sites	Time Needed to Implement	Time Needed to Realize Benefits	Implementing Entities	Estimated Cost	Implement-ability (L-M-H)	Comment
		Butte Meadows Creek, Chaparral Creek						
	Place LWD	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	3 - 5 Years	< 3 Years	Yakama Nation	$100,000 – 500,000	High	
	Restore stream length	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	3 - 5 Years	< 3 Years	Yakama Nation	$500,000 – 1,000,000	High	
	Short-term introduction of spawning gravel	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	< 3 Years	< 3 Years	Yakama Nation	$100,000 – 500,000	High	Improved side-channel habitat, pool quality and quantity will improve rearing habitat and juvenile growth and survival. Numerous private sections in the upper portion of the Diamond Fork watershed were purchased by a developer. WaDNR parcels that are currently in State Lands could be reclassified as Natural Areas.
	Restore side-channel connectivity	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	3 - 5 Years	3 - 5 Years	Yakama Nation	$100,000 – 500,000	Moderate	
	Restore stream length and place LWD	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows	3 - 5 Years	< 3 Years	Yakama Nation	$500,000 – 1,000,000	Moderate	

Action category	Actions	Affected Sites	Time Needed to Implement	Time Needed to Realize Benefits	Implementing Entities	Estimated Cost	Implement-ability (L-M-H)	Comment
		Creek, Chaparral Creek						
	Restore channel morphology	Piscoe Creek, Chaparral Creek, Diamond Fork, Coyote Creek	3 - 5 Years	3 - 5 Years	Yakama Nation	$500,000 – 1,000,000	Moderate	Lack of riparian canopy and pool habitat; sediment load. High temperatures during summer low flows and formation of anchor ice in winter caused by lack of cover and pools limit productivity. Rearing habitat, juvenile survival will be improved.
	Riparian re-vegetation	Piscoe Creek, Chaparral Creek, Diamond Fork, Coyote Creek	5 - 10 Years	5 - 10 Years	Yakama Nation	$100,000 – 500,000	High	
Land-use	Disconnect roads from streams	Piscoe Creek, Chaparral Creek, Diamond Fork, Coyote Creek	3 - 5 Years	5 - 10 Years	Yakama Nation	$100,000 – 500,000	Moderate	
	Relocate/ soften floodplain infrastructure; Perforate roads to allow peak flows to move onto floodplain; Close/relocate ORV trails	Chaparral Creek, Coyote Creek, McCreedy Creek, Butte Meadows Creek, Klickitat R. from Castle Falls (RM 65.75) to RM 87.05, upper Diamond Fork	3 - 5 Years	5 -10 Years	Yakama Nation, State land management agency (i.e. WADNR)	$500,000 – 1,000,000	Moderate	Actions will lead to improved floodplain connectivity, pool quality, gravel sorting and stability, thus increasing available refugia, improving rearing habitat, and juvenile and egg-to-fry survival.
	Riparian forest management and planning: plan to leave buffer strips in riparian forest zones	Chaparral Creek, McCreedy Creek, Piscoe, Diamond Fork, Coyote, Butte Meadows, Klickitat R. from Castile Falls (RM 65.75) to RM 87.05	5 - 10 Years	5 -10 Years	Yakama Nation, State land management agency (i.e. WADNR)	$0 - 100,000	Moderate	Point source delivery of fine sediment from roads; stream bank mass wasting. Actions will decrease run-off/peak flows and sediment introduction, decrease interception and incision of shallow groundwater flows, and restore valley-bottom morphology and potential for channel migration. Spawning and rearing habitat will be improved; egg-to-fry survival will
	Disconnect roads from stream network; relocate/	Chaparral Creek, McCreedy Creek, Piscoe, Diamond Fork,	5 - 10 Years	5 -10 Years	Yakama Nation, State land management agency (i.e.	$500,000 – 1,000,000	High	

Action category	Actions	Affected Sites	Time Needed to Implement	Time Needed to Realize Benefits	Implementing Entities	Estimated Cost	Implement -ability (L-M-H)	Comment
	abandon mid-slope roads where possible; relocate/abandon on valley-bottom roads where possible. Improve surface and drainage characteristics of roads in tributary watersheds	Coyote, Butte Meadows, Klickitat R. from Castile Falls (RM 65.75) to RM 87.05			WADNR)			increase.
	Limit riparian livestock grazing	Chaparral Creek, McCreedy Creek, Piscoe, Diamond Fork, Coyote, Butte Meadows, Klickitat R. from Castile Falls (RM 65.75) to RM 87.05	< 3 Years	< 3 Years	Yakama Nation, State land management agency (i.e. WADNR), Private landowner	$0 - 100,000	High	
	Decrease fine sediment production and delivery from roads and other land uses	Klickitat River from RM 70.5 to RM 87.05, Chaparral Creek, Diamond Fk., Piscoe Creek	3 - 5 Years	5 -10 Years	Yakama Nation	$100,000 – 500,000	High	Negative impact of reduction in food web greater on fry colonization in mainstem than in tributaries. Reducing sediment inputs will increase aquatic insect production for food. Carcass analogs may provide a temporary food source for juveniles. Actions will improve primary and secondary productivity by improving substrate conditions.
Water quality	Short-term fertilization of stream with carcasses or carcass analogs	Klickitat River from RM 70.5 to RM 87.05, Chaparral Creek, Diamond Fk., Piscoe Creek	< 3 Years	< 3 Years	Yakama Nation	$100,000 – 500,000	High	
Population management	Eliminate illegal harvest by enforcing tribal and sport regulations	upper Klickitat mainstem	< 3 Years	< 3 Years	Yakama Nation	$0 - 100,000	Moderate	Infrequent/episodic occurrence, but moderate to high impact when it does occur

Table A-2: Major Spawning Area (MaSA) Actions and Costs

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
Upper Klickitat MaSA	Fish Passage - Culvert Replacement	# of installations	7	$100,000	$700,000
	Instream - Streambank Stabilization	length treated in miles	2	$100,000	$200,000
	Instream - Channel Connectivity	length treated in miles	12	$65,000	$780,000
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	4	$475,200	$1,900,800
	Instream - Deflectors/ barbs	length treated in miles	1	$35,000	$35,000
	Instream - Off channel habitat	length treated in miles	1	$105,600	$105,600
	Instream - Spawning Gravel Placement	length treated in miles	1	$90,000	$90,000
	Instream - Log (control) weirs	# of structures	10	$2,500	$25,000
	Instream - Rock (control) weirs	# of structures	14	$2,500	$35,000
	Instream - Large Woody Debris	# of structures	20	$1,000	$20,000
	Instream - Structure/ Log Jam	# of structures	125	$15,000	$1,875,000
	Instream - Beaver Introduction	# of beavers introduced	20	$350	$7,000
	Riparian - Livestock Water Development	# of installations	3	$6,000	$18,000
	Riparian - Water Gap Development	# of installations	0	$1,200	$0
	Riparian - Fencing	miles	25	$10,000	$250,000
	Riparian - Planting	species; area treated (acres)	200	$2,000	$400,000
	Riparian - Weed Control	species; area treated (acres)	200	$1,000	$200,000
	Sediment Reduction - Road Reconstruction	miles			
	Sediment Reduction - Road Relocation	miles	8	$120,000	$960,000
	Sediment Reduction - Road Stream Crossing Improvements (Rocked Ford)	miles	4	$1,800	$7,200
	Sediment Reduction - Road Drainage System Improvements	miles	60	$6,000	$360,000
	Sediment Reduction - Road Obliteration	miles	1	$7,000	$7,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	15	$1,400	$21,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	60	$600	$36,000
	Upland- Agriculture - Fencing	miles	2	$8,800	$17,600
	Upland- Agriculture - Water Development	# of installations	3	$2,400	$7,200
	Upland- Vegetation - Planting	area treated (acres)	35	$2,000	$70,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	20	$250	$5,000

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Upland- Vegetation - Slope Stabilization	area treated (acres)	80	$180	$14,400
	Land Protected, Acquired, or Leased - Streambank Protected	miles	4	$320,000	$1,280,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	10	$4,000	$40,000
	Nutrient Enrichment - Carcass Placement	area treated (acres)			
	Project maintenance - Site Maintenance	miles	12	$4,000	$48,000
					$9,514,800
White Creek MaSA	Fish Passage - Culvert Replacement	# of installations	9	$100,000	$900,000
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	14	$475,200	$6,652,800
	Instream - Spawning Gravel Placement	length treated in miles	5	$90,000	$450,000
	Instream - Large Woody Debris	# of structures	150	$1,000	$150,000
	Instream - Structure/ Log Jam	# of structures	150	$15,000	$2,250,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Water Gap Development	# of installations	3	$1,200	$3,600
	Riparian - Fencing	miles	6.5	$10,000	$65,000
	Riparian - Planting	species; area treated (acres)	400	$2,000	$800,000
	Riparian - Weed Control	species; area treated (acres)	2	$1,000	$2,000
	Sediment Reduction - Road Reconstruction	miles	4	$8,000	$32,000
	Sediment Reduction - Road Relocation	miles	12	$60,000	$720,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.1	$950,400	$95,040
	Sediment Reduction - Road Drainage System Improvements	miles	50	$6,000	$300,000
	Sediment Reduction - Road Obliteration	miles	5	$7,000	$35,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	50	$1,400	$70,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	40	$600	$24,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	40	$250	$10,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	2	$160,000	$320,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	15	$4,000	$60,000
	Project maintenance - Site Maintenance	miles	14	$4,000	$56,000
					$12,998,940

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
Middle Klickitat MaSA	Fish Passage - Culvert Replacement	# of installations	1	$250,000	$250,000
	Instream - Channel Connectivity	length treated in miles	4.5	$475,200	$2,138,400
	Instream - Off channel habitat	length treated in miles	2.5	$422,400	$1,056,000
	Instream - Spawning Gravel Placement	length treated in miles	1	$90,000	$90,000
	Instream - Large Woody Debris	# of structures	25	$1,000	$25,000
	Instream - Structure/ Log Jam	# of structures	45	$35,000	$1,575,000
	Riparian - Fencing	miles	2	$10,000	$20,000
	Riparian - Planting	species; area treated (acres)	110	$5,000	$550,000
	Riparian - Weed Control	species; area treated (acres)	30	$1,600	$48,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.05	$950,400	$47,520
	Sediment Reduction - Road Drainage System Improvements	miles	15	$6,000	$90,000
	Sediment Reduction - Road Obliteration	miles	13	$80,000	$1,040,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	60	$1,400	$84,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	35	$600	$21,000
	Upland- Vegetation - Planting	area treated (acres)	1280	$450	$576,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	20	$1,600	$32,000
	Upland- Vegetation - Slope Stabilization	area treated (acres)	10	$1,800	$18,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	2	$640,000	$1,280,000
	Project maintenance - Site Maintenance	miles	15	$8,000	$120,000
					$9,060,920
Lower Klickitat MaSA	Fish Passage - Culvert Replacement	# of installations	1	$350,000	$350,000
	Instream - Channel Connectivity	length treated in miles	0.9	$844,800	$760,320
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	2	$1,161,600	$2,323,200
	Instream - Deflectors/ barbs	length treated in miles	35	$35,000	$1,225,000
	Instream - Off channel habitat	length treated in miles	0.4	$1,161,600	$464,640
	Instream - Spawning Gravel Placement	length treated in miles	2.5	$90,000	$225,000
	Instream - Log (control) weirs	# of structures	10	$2,500	$25,000
	Instream - Rock (control) weir	# of structures	8	$2,500	$20,000
	Instream - Structure/ Log Jam	# of structures	25	$45,000	$1,125,000

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Riparian - Water Gap Development	# of installations	4	$1,200	$4,800
	Riparian - Planting	species; area treated (acres)	320	$4,500	$1,440,000
	Riparian - Weed Control	species; area treated (acres)	80	$1,600	$128,000
	Sediment Reduction - Road Drainage System Improvements	miles	15	$4,200	$63,000
	Sediment Reduction - Road Obliteration	miles	3.5	$60,000	$210,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	15	$1,400	$21,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	35	$600	$21,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	120	$1,600	$192,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	4	$800,000	$3,200,000
	Project maintenance - Site Maintenance	miles		$4,000	
					$11,797,960
Swale Creek MiSA	Instream- Wetland - Wetland Restoration	area treated (acres)	3200	$5,000	$16,000,000
	Instream - Channel Connectivity	length treated in miles	1.2	$475,200	$570,240
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	17	$950,400	$16,156,800
	Instream - Spawning Gravel Placement	length treated in miles	8.5	$90,000	$765,000
	Instream - Structure/ Log Jam	# of structures	55	$15,000	$825,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Planting	species; area treated (acres)	250	$2,000	$500,000
	Riparian - Weed Control	species; area treated (acres)	250	$1,600	$400,000
	Sediment Reduction - Road Drainage System Improvements	miles	4	$2,200	$8,800
	Sediment Reduction - Road Obliteration	miles	4	$60,000	$240,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	25	$1,400	$35,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	40	$600	$24,000
	Upland- Vegetation - Planting	area treated (acres)	800	$450	$360,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	800	$1,600	$1,280,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	17	$320,000	$5,440,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	50	$4,000	$200,000

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Project maintenance - Site Maintenance	miles	17	$4,000	$68,000
					$42,876,340
Klickitat Canyon MiSA	Sediment Reduction - Road Stream Crossing Improvements (Rocked Ford)	miles	0.1	$316,800	$31,680
	Sediment Reduction - Road Drainage System Improvements	miles	55	$4,500	$247,500
	Sediment Reduction - Road Obliteration	miles	2	$15,000	$30,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	50	$1,400	$70,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	35	$600	$21,000
	Project maintenance - Site Maintenance	miles	55	$4,000	$220,000
					$620,180
Lower Little Klickitat MiSA	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	6	$844,800	$5,068,800
	Instream - Spawning Gravel Placement	length treated in miles	3	$90,000	$270,000
	Instream - Large Woody Debris	# of structures	20	$1,000	$20,000
	Instream - Structure/ Log Jam	# of structures	18	$15,000	$270,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Planting	species; area treated (acres)	160	$2,000	$320,000
	Riparian - Weed Control	species; area treated (acres)	20	$1,600	$32,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.1	$950,400	$95,040
	Sediment Reduction - Road Drainage System Improvements	miles	10	$4,500	$45,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	35	$1,400	$49,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	20	$600	$12,000
	Upland- Vegetation - Planting	area treated (acres)	800	$450	$360,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	200	$1,600	$320,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	12	$80,000	$960,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	50	$4,000	$200,000
	Project maintenance - Site Maintenance	miles	6	$4,000	$24,000
					$8,049,340

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
Upper Little Klickitat MaSA	Fish Passage - Culvert Replacement	# of installations	1	$125,000	$125,000
	Instream - Channel Connectivity	length treated in miles	0.5	$475,200	$237,600
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	22	$475,200	$10,454,400
	Instream - Spawning Gravel Placement	length treated in miles	11	$90,000	$990,000
	Instream - Large Woody Debris	# of structures	55	$1,000	$55,000
	Instream - Structure/ Log Jam	# of structures	35	$9,000	$315,000
	Instream - Beaver Introduction	# of beavers introduced	15	$350	$5,250
	Riparian - Livestock Water Development	# of installations	40	$3,200	$128,000
	Riparian - Water Gap Development	# of installations	40	$1,200	$48,000
	Riparian - Fencing	miles	36	$10,000	$360,000
	Riparian - Planting	species; area treated (acres)	800	$2,000	$1,600,000
	Riparian - Weed Control	species; area treated (acres)	400	$1,600	$640,000
	Sediment Reduction - Road Reconstruction	miles	0.5	$3,000,000	$1,500,000
	Sediment Reduction - Road Stream Crossing Improvements (Rocked Ford)	miles	10	$1,800	$18,000
	Sediment Reduction - Road Drainage System Improvements	miles	30	$11,000	$330,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	20	$1,400	$28,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	40	$1,600	$64,000
	Upland- Vegetation - Planting	area treated (acres)	12800	$450	$5,760,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	300	$800	$240,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	22	$80,000	$1,760,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	5	$4,000	$20,000
	Project maintenance - Site Maintenance	miles	38	$4,000	$152,000
					$24,830,250
Upper Middle Klickitat MiSA	Instream - Structure/ Log Jam	# of structures	30	$28,000	$840,000
	Riparian - Planting	species; area treated (acres)	40	$5,000	$200,000
	Sediment Reduction - Road Reconstruction	miles	2	$26,000	$52,000
	Sediment Reduction - Road Stream Crossing Improvements (Rocked Ford)	miles	6	$1,800	$10,800
	Sediment Reduction - Road Drainage System Improvements	miles	16	$3,600	$57,600
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	115	$1,600	$184,000

MSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Project maintenance - Site Maintenance	miles	18	$1,500	$27,000
				$1,371,400	Assumes river route remains in place with only drainage improvements; estimates do not include roads falling under Forest and Fish jurisdiction
Trout Creek MiSA	Fish Passage - Culvert Replacement	# of installations	3	$250,000	$750,000
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	10	$475,200	$4,752,000
	Instream - Spawning Gravel Placement	length treated in miles	10	$90,000	$900,000
	Instream - Large Woody Debris	# of structures	15	$1,200	$18,000
	Instream - Structure/ Log Jam	# of structures	30	$9,000	$270,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Planting	species; area treated (acres)	60	$3,900	$234,000
	Sediment Reduction - Road Reconstruction	miles	18	$26,000	$468,000
	Sediment Reduction - Road Stream Crossing Improvements (Rocked Ford)	miles	5	$1,800	$9,000
	Sediment Reduction - Road Drainage System Improvements	miles	25	$3,800	$95,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	25	$1,400	$35,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	15	$600	$9,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	40	$1,600	$64,000
	Project maintenance - Site Maintenance	miles	10	$4,000	$40,000
					$7,647,500
West Fork Klickitat MaSA	Sediment Reduction - Road Reconstruction	miles	0.5	$1,200,000	$600,000
	Sediment Reduction - Road Drainage System Improvements	miles	15	$5,200	$78,000
	Project maintenance - Site Maintenance	miles	0.5	$12,000	$6,000
					$684,000
[a] from Table 1 in Plummer guidance document					

Appendix B

Hatchery Genetic Management Plans for

Klickitat River Native Summer Steelhead,
Klickitat Spring Chinook Production Program-Klickitat Hatchery,
Klickitat Hatchery Coho,
and Klickitat Fall Chinook

Klickitat River
Native Summer Steelhead

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HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

DRAFT

Hatchery Program	Klickitat River-Native Summer Steelhead
Species or Hatchery Stock	*Oncorhynchus mykiss* Summer Steelhead
Agency/Operator	Yakama Nation
Watershed and Region	Klickitat Subbasin/Columbia Gorge Province
Date Submitted	February 2008
Date Last Updated	February 2008

Section 1: General Program Description

1.1 Name of hatchery or program.

Klickitat River-Local Broodstock

1.2 Species and population (or stock) under propagation, and ESA status.

Summer Steelhead – *Oncorhynchus mykiss*

ESA Status: Threatened

1.3 Responsible organization and individuals.

Name (and title):	Jason Rau (Complex Manager)
	Bill Sharp (YKFP Klickitat Coordinator)
Agency or Tribe:	Yakama Nation
Address:	PO Box 151 Toppenish WA 98948
Telephone:	(509) 865-5121
Fax:	(509) 865-6293
Email:	jayrau@ykfp.org sharp@yakama.com

Other agencies, Tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program.

Co-operators	**Role**
Washington Department of Fish and Wildlife	Hatchery Specialist 1
National Marine Fisheries Service	Manager of Mitchell Act Funds

1.4 Funding source, staffing level, and annual hatchery program operational costs.

Funding Sources
Mitchell Act and BPA

Operational Information	Contract Number NA06NMF4360230
Full time equivalent staff	5 (1 new staff)
Annual operating cost (dollars)	$203,000 (NPCC Step-1 estimate)

1.5 Location(s) of hatchery and associated facilities.

Broodstock source	Klickitat River Summer Run Steelhead
Broodstock collection location (stream, RKm, subbasin)	Lyle Falls (RKm 3.5) and Castile Falls
Adult holding location (stream, RKm, subbasin)	Klickitat Hatchery (RKm 68)
Spawning location (stream, RKm, subbasin)	Klickitat Hatchery (RKm 68)
Incubation location (facility name, stream, RKm, subbasin)	Klickitat Hatchery (RKm 68)
Rearing location (facility name, stream, RKm, subbasin)	Klickitat Hatchery (RKm 68), and McCreedy Creek Acclimation Facility (RKm 113)

1.6 Type of program.

Integrated Harvest and Conservation

1.7 Purpose (Goal) of program.

- Increase natural fish abundance to levels that allow for the delisting of the species.
- Maintain current sport and tribal fishing harvest levels in the Subbasin; while minimizing adverse impacts to native stocks.
- Eliminate non-native steelhead hatchery releases in the Subbasin.

1.8 Justification for the program.

- The YN is required under U.S. vs. Oregon treaty obligations to release steelhead for harvest into the Klickitat River.
- Conservation of Columbia River fisheries resources as defined and required by the Mitchell Act.
- Summer steelhead are listed as Threatened under ESA. Steelhead abundance, diversity and spatial structure need to be increased to achieve recovery objectives identified by NOAA Fisheries for this species.

This program replaces the Direct Plant Skamania Summer Steelhead program which used a non-native fish stock to provide harvest benefits in the basin. The new program utilizes the locally adapted native stock to not only provide harvest opportunity but also to increase the abundance, diversity and spatial structure of this listed population which will lead to the delisting of the species under ESA. However, the use of hatchery smolt releases to achieve conservation objectives would not be implemented for 9 years to determine if steelhead are able to colonize habitat above Castile Falls without intervention with hatchery production.

In order to minimize impacts on listed fish the following actions are included in this HGMP:

Summary of risk aversion measures for the Klickitat summer steelhead program.

Potential Hazard	**Risk Aversion Measures**
Water Withdrawal	Water rights are formalized through trust water right S4-*07272 from the Department of Ecology. Monitoring and measurement of water usage is reported in monthly NPDES reports.
Intake Screening	YN has requested funding for future scoping, design, and construction work of a new river intake system to meet NOAA compliance (Mitchell Act Intake and Screening Assessment 2002). New screens will prevent entrainment or impingement of listed and unlisted fish stocks.
Effluent Discharge	This facility operates under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) administered by the Environmental Protection Agency (EPA). Following procedures outlined in this program reduces impacts to stream water quality from hatchery operations.
Broodstock Collection & Adult Passage	Broodstock will be collected at the new Lyle Falls Fishway at RKm 2.2, Castile Falls RKm 102 and the Klickitat Hatchery. New facilities will be based on recent NMFS passage criteria thereby reducing mortality rates on listed steelhead.
Disease Transmission	*Fish Health Policy in the Columbia Basin*. Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).
Competition & Predation	Hatchery steelhead smolts will not be released above Castile Falls to prevent competition and predation on natural origin fish. Predation rates (index) will be developed for hatchery steelhead released below Castile Falls to determine impacts to juvenile spring Chinook and steelhead.

1.9 List of program "Performance Standards".

See section 1.10.

1.10 List of program "Performance Indicators", designated by "benefits" and "risks".

1.10.1 Benefits:

Benefits		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Assure that hatchery operations support Columbia River fish Mgt. Plan *(US v Oregon)*, production and harvest objectives	Achieve 10 year average of 2.0% smolt to adult survival (SAR) for both release groups of program. Manage the composite population for a PNI value of 0.67 or greater (up to 0.9). Support current levels of harvest for terminal treaty and sport fisheries provided from previous Skamania origin hatchery releases. (~2,000). Long-term objective of providing 2,400 fish to terminal tribal and sport fisheries..	Survival and contribution to fisheries will be estimated for each brood year released. Work with co-managers to manage adult fish returning in excess of broodstock need.
Maintain outreach to enhance public understanding, participation, and support of Yakama Nation hatchery programs	Provide information about agency programs to internal and external audiences. For example, local schools and special interest groups tour the facility to better understand hatchery operations. Off-station efforts may include festivals, classroom participation, stream adoptions, and fairs.	Evaluate use and/or exposure of program materials and exhibits as they help support goals of the information and education program. Record on-station organized education and outreach events.
Program contributes to fulfilling tribal trust responsibility mandates and treaty rights	Follow pertinent laws, agreements, policies and executive and judicial orders on consultation and coordination with Native American tribal governments	Participate in annual coordination meetings between the co-managers to identify and report on issues of interest, coordinate management, and review programs (FBD process).
Implement measures for broodstock management to maintain integrity and genetic diversity. Maintain effective population size.	A minimum of 70 adults are to be collected throughout the spawning run in proportion to timing, age, and sex composition of the natural return.	Annual run timing, age and sex composition, and return timing data are collected.
Region-wide, groups are marked in a manner consistent with information needs and protocols to estimate impacts to natural and hatchery origin fish	Use mass-mark (adipose-fin clip) for selective fisheries with additional release groups elastomer tagged if needed.	Returning fish are sampled throughout their return for length, sex, and marks.
Maximize survival at all life stages using disease control and disease prevention techniques. Prevent introduction, spread or amplification of fish pathogens. Follow Co-managers Fish Health Disease Policy WDFW and NWIFC 1998).	Necropsies of fish to assess health, nutritional status, and culture conditions	USFWS staff to inspect adult broodstock yearly for pathogens and parasites and monitor juvenile fish on a monthly basis to assess health and detect potential disease problems. As necessary, USFWS recommends remedial or preventative measures to prevent or treat disease, with administration of therapeutic and prophylactic treatments as necessary. A fish health database will be maintained to identify trends in fish health and disease and implement fish health management plans based on findings.
	Release and/or transfer exams for pathogens and parasites	1 to 6 weeks prior to transfer or release, fish are examined in accordance with the Co-managers' Fish Health Policy
	Inspection of adult broodstock for pathogens and parasites	At spawning, adult broodstock, in lots of 60, are examined for pathogens
	Inspection of off-station fish/eggs prior to transfer to hatchery for pathogens and parasites	Controls of specific fish pathogens through eggs/fish movements are conducted in accordance with Co-managers' Fish Health Disease Policy.

1.10.2 Risks:

Risks		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Minimize impacts and/or interactions to ESA-listed fish	Hatchery operations comply with all federal regulations. Hatchery juveniles are raised to smolt-size (6-8 fish/lb) and released from the hatchery at a time that encourages rapid migration downstream. Mass mark production fish to identify them from naturally produced fish (except CWT only groups)	As identified in this HGMP: Monitor size, number, date of release and mass mark quality. Collect real-time DNA data to identify origin of adult fish, thereby ensuring that only Klickitat River fish are used as broodstock. Estimate number of hatchery fish on spawning grounds.
Artificial production facilities are operated in compliance with all applicable fish health guidelines, facility operation standards and protocols including IHOT, Co-managers' Fish Health Policy, and drug usage mandates from the Federal Food and Drug Administration	Hatchery goal is to prevent the introduction, amplification or spread of fish pathogens that might negatively affect the health of both hatchery and naturally reproducing stocks and to produce healthy smolts that will contribute to the goals of this facility.	Pathologists from the USF&WS Lower Columbia Fish Health Center will monitor the program monthly. Exams performed at each life stage may include tests for virus, bacteria, parasites, and/or pathological changes.
Ensure hatchery operations comply with state and federal water quality and quantity standards through proper environmental monitoring	NPDES permit compliance WDFW water right permit compliance	Flow and discharge reported in monthly NPDES reports.
Water withdrawals and instream water diversion structures for hatchery facility will not affect spawning behavior of natural populations or impact juveniles.	Hatchery intake structures meet state and federal guidelines where located in fish-bearing streams.	Barrier and intake structure compliance assessed and needed fixes are prioritized.
Hatchery operations comply with ESA responsibilities	YN completes an HGMP and is issued a federal and state permit when applicable.	Identified in HGMP and Biological Opinion for hatchery operations.
Harvest of hatchery-produced fish minimizes impact to wild populations	Harvest is regulated to meet appropriate biological assessment criteria. Mass mark juvenile hatchery fish prior to release to enable state agencies to implement selective fisheries.	Harvests are monitored by agencies and tribes to provide up to date information.

1.11.1 Proposed annual broodstock collection level (maximum number of adult fish).

Approximately 70-80 NOR adults will be used for broodstock each year. This should result in an egg-take of approximately 152,000 and a release of 130,000 juveniles.

1.11.2 Proposed annual fish release levels (maximum number) by life stage and location.

Age Class	Max. No.	Size (fpp)	Release Date	Location			
				Stream	Release Point (RKm)	Major Water-shed	Eco-province
Yearling	130,000	6-8	April-May	Klickitat	68	Klickitat	Columbia Gorge

1.12 Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.

Because this is a new program, no survival data are available. The program assumes an initial SAR of 2.0%. Adult returns to the Subbasin are expected to range from 390 (0.3% SAR) to 5,200 (4.0% SAR) and average 2,600 (2.0% SAR).

1.13 Date program started (years in operation), or is expected to start.

New program estimated start date: 2009.

1.14 Expected duration of program.

Continuous until natural production increases to the point where conservation and harvest objectives can be achieved without the program.

1.15 Watersheds targeted by program.

Klickitat Subbasin/Columbia Gorge Province

1.16 Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

Alternative programs considered are presented below. More information on these alternatives can be found in the Klickitat River Anadromous Fisheries Master Plan (Yakama Nation 2008)

1.16.1 Potential Alternatives to the Current Program

Alternative 1- Maintain Existing Program

This management alternative would maintain the current hatchery operations in the Klickitat consisting of a 130 k release of hatchery Skamania-origin steelhead. The juveniles are reared to a smolt age of 1 yr at the Skamania Hatchery and released in the lower River. This is not the preferred alternative due to the genetic introgression risk associated with the domesticated imported hatchery stock and the Klickitat indigenous stock that could result in loss of genetic diversity.

Alternative 2- Eliminate Hatchery Program and Improve Habitat

Analyses indicate that, with optimistic assumptions regarding the effectiveness of the habitat actions, the adult escapement target of 2,500 adults may be achieved. However, the run size back to the Subbasin was insufficient to meet the 2,400 harvest objective for combined tribal and sport fisheries. This alternative was therefore rejected.

Section 2: Program Effects on ESA-Listed Salmonid Populations

2.1 List all ESA permits or authorizations in hand for the hatchery program.

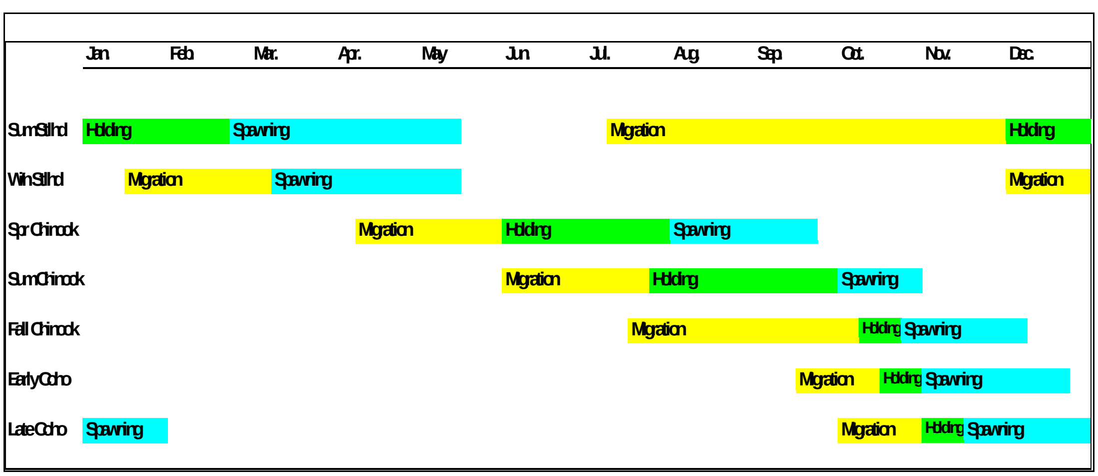
- The existing Program is described in the “Biological Assessment for the Operation of Hatcheries Funded by the National Marine Fisheries Service” (March 1999)
- Statewide Section 6 consultation with USFWS for interactions with Bull Trout
- To satisfy Section 7 consultations, YN is writing HGMPs to cover all stock/programs in the Klickitat River including fall chinook, spring Chinook, steelhead and coho released from Klickitat Hatchery.

2.2.1 Descriptions, status and projected take actions and levels for ESA-listed natural populations in the target area.

The following ESA-listed natural salmonid populations occur in the Klickitat Subbasin where the program fish are released:

ESA-listed stock	Status	Take Level	Action
Summer Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls, and Castile Falls
Winter Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls, Castile Falls
Bull Trout – Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls, Castile Falls

Adult and juvenile run-timing for listed steelhead and other fish species are presented in the figure below.



The majority of the steelhead population is found from the mouth of the Klickitat River to Castile Falls. Steelhead access to areas above Castile Falls has been limited due to poor natural migration conditions at the falls. Steelhead spawning is concentrated between RKm 8 and 80. Tributary spawning occurs in Swale, Swift, Summit and White creeks, the lower Little Klickitat River, and other small tributaries (Appendix A).

Resident bull trout are found primarily in the West Fork Klickitat River. However, bull trout likely use the mainstem Klickitat River as a migration corridor (Appendix A).

Identify the ESA-listed population(s) that will be <u>directly</u> affected by the program.

Mid-Columbia Steelhead will be directly affected by the program.

Identify the ESA-listed population(s) that may be <u>incidentally</u> affected by the program.

Steelhead and Bull Trout may be incidentally affected by the program.

2.2.2 Status of ESA-listed salmonid population(s) affected by the program.

Describe the status of the listed natural population (s) relative to "critical" and "viable" population thresholds.

Mid-Columbia River Steelhead *(Oncorhynchus mykiss*) were listed as threatened under the ESA on March 19, 1998. The MCR steelhead ESU includes winter and summer steelhead in tributaries to the Columbia River between Mosier Creek and the Yakama River. The Biological Review Team (BRT) concluded that the Middle Columbia steelhead ESU is not presently in danger of extinction, but reached no conclusion regarding its likelihood of becoming endangered in the foreseeable future. Winter steelhead are reported within this ESU only in the Klickitat River and Fifteenmile Creek.

Information on steelhead abundance, productivity, and population growth trends is reported in NOAA 2005.

Status of summer and winter runs:

The existence of naturally spawning winter steelhead was confirmed in the early 1980s and winter steelhead are presumed to be indigenous. Howell et al. (1985) recognized both summer and winter races of steelhead in the Klickitat Subbasin, with an adult winter steelhead migration period of January through May and a spawning period of March through June. To protect the winter run, current regulations prohibit sport fishing for steelhead in the Klickitat River from December through May; the treaty fishery is closed from January through March. Both seasons have been longer in previous years.

The most comprehensive set of steelhead spawner survey data was collected between 1986 and 2006. Redd counts over these years indicate an average escapement of 260 fish. This figure is undoubtedly an underestimate due to the inherent difficulty in conducting accurate counts during spring flow conditions. Mainstem spawning distribution is concentrated between RKm 8 and RKm 80.0, with occasional spawning above Castile Falls. Tributary spawning occurs in Swale, Wheeler, Summit and White creeks, and the Little Klickitat River.

Summary of Klickitat River Steelhead terminal harvest, estimated escapement and total run size to the mouth (1986-2006)

		Sport			Tribal				
Year	Run[1]	Hatchery	Wild	Total	Hatchery[2]	Wild[2]	Total	Escape-ment[3]	Redds[4]
1986-87	9,834	1,426	54	1,480	5,107	901	6,008	2,346	
1987-88	3,751	1,480	34	1,514	1,141	201	1,342	895	
1988-89	4,208	1,718	0	1,718	1,263	223	1,486	1,004	
1989-90	1,702	833	0	833	536	95	631	238	95
1990-91	2,957	1,055	0	1,055	1,464	258	1,722	180	72
1991-92	3,595	823	8	831	1,620	286	1,906	858	
1992-93	3,251	1,260	0	1,260	1,033	182	1,215	776	
1993-94	3,402	1,211	25	1,236	1,151	203	1,354	812	
1994-95	1,915	857	34	891	482	85	567	457	
1995-96	1,805	864	9	873	433	76	509	423	169
1996-97	1,082	608	14	622	241	43	284	176	71
1997-98	2,185	1,062	18	1,080	455	80	535	570	228
1998-99	1,521	650	12	662	224	39	263	596	239
1999-00	1,725	575	28	603	214	0	214	908	363
2000-01	2,851	1,433	59	1,492	495	67	562	797	319
2001-02	5,264	3,708	16	3,724	724	55	779	761	304
2002-03	6,022	3,552	97	3,649	1285	363	1,648	725	290
2003-04	2,766	1,673	0	1,673	369	151	520	573	229
2004-05	2,957	1,658	0	1,658	747	153	900	399	160
2005-06[5]		1,115	0	1,115	368	98	466		
Avg:	3,305	1,378	20	1,398	968	178	1,146	710	212

Columbia Basin DPS Bull Trout *(Salvelinus confluentus*) June 10, 1998 (63 FR 31647), Threatened.

The Fish and Wildlife Service issued a final rule listing the Columbia River and Klamath River populations of bull trout *(Salvelinus confluentus*) as a threatened species under the Endangered Species Act on June 10, 1998 (63 FR 31647). The Columbia River Distinct Population Segment is threatened by habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, and past fisheries management practices such as the introduction of non-native species.

The Lower Columbia Recovery Unit Team identified two core areas (Lewis and Klickitat rivers) within the recovery unit. The Klickitat Core Area includes all tributaries downstream to the confluence with the Columbia River. Recent evidence indicates that both resident and adfluvial bull trout are present in the Subbasin. There are numerous confirmed and anecdotal reports of bull trout in the mainstem Klickitat River from the mouth up to the area below Castile Falls. Sizes reported are indicative of an adfluvial life history. Presence of resident populations has also been documented in the West Fork Klickitat River, Fish Lake Stream, Little Muddy Creek, Trappers Creek, Clearwater Creek, Two Lakes Stream, and an unnamed tributary to Fish Lake Stream (all within the West Fork Klickitat watershed).

The abundance of the stock in the Klickitat River is poorly known. There are insufficient data to make an assessment. However, it appears that there are very few bull trout in the lower- to mid-Klickitat drainage. Bull trout appear to be more abundant in the upper drainage where habitat conditions are more favorable.

Preliminary results of recent genetic analysis indicate that resident bull trout in the Klickitat Subbasin are genetically distinct from other Columbia tributary populations, but that fish in two West Fork Klickitat tributaries (Trappers and Clearwater creeks) do not differ significantly from each other.

The impacts of hatchery salmon and steelhead in the main Klickitat River on bull trout. Is unknown. Generally, in drainages colonized by anadromous salmon, steelhead and char successfully co-exist by occupying a different ecological niche. However, negative interactions (predation) may occur when hatchery fish are released near char spawning and rearing areas.

2.2.3 Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of <u>listed</u> fish in the target area, and provide estimated annual levels of take.

Describe hatchery activities: The following activities are general hatchery actions identified in the ESA Section 7 Consultation "Biological Opinion on Artificial Propagation in the Columbia River Basin" (March 29, 1999).

Broodstock Program:

Broodstock Collection: Adult trapping and hatchery broodstock collection activities will take up to 80 NOR summer steelhead each year. Because all adult collection facilities will be designed to meet NMFS standards, few fish should be injured or killed due to fish handling and sorting procedures. This assumption is supported by historical data which show that no listed fish mortalities have been observed during this operation of the Klickitat Hatchery

Genetic introgression: Straying of hatchery fish into natural spawning areas may lead to genetic introgression. DNA samples will be collected from both hatchery and natural fish populations to determine level of effect, if any, over time. Additionally, fish passage operations and harvest rates will be adjusted to achieve a PNI of 0.67 for the composite hatchery and natural stock.

Rearing Program:

Operation of Hatchery Facilities: Expect some losses in juvenile rearing in the hatchery environment (0%-15% loss from egg-to-smolt of all eggs cultured).

Water diversion: Water is diverted from the stream for hatchery operations. This results in a decrease in the amount and quality of approximately 0.25 mile of stream habitat. The loss in habitat may result in a decrease in steelhead and bull trout abundance; although loss has not been quantified and is expected to be negligible. In addition, The Mitchell Act Intake and Screening Assessment (NOAA April 2002) has identified design and alternatives needed to get existing structures in compliance with NOAA fish screening standards. From the assessment, YN has been requesting funding for future scoping, design, and construction work of a new intake system at the Klickitat Hatchery.

Water Quality: This facility operates under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). Monthly and annual reports on water quality sampling, use of chemicals at this facility, compliance records are available from DOE. Discharges from the cleaning treatment system are monitored as follows:

Total Suspended Solids (TSS): Collected 1 to 2 times per month on composite effluent, maximum effluent and influent samples.

Settleable Solids (SS): Collected 1 to 2 times per week on effluent and influent samples.

In-hatchery Water Temperature: Daily maximum and minimum readings are collected.

Water quality monitoring is not expected to result in the take of listed species because fish are not affected by the sample collection process.

Disease: Disease outbreaks in the hatchery could cause significant adult, egg, or juvenile mortality. Over the years, rearing densities, disease prevention and fish health monitoring have greatly improved the health of the programs at Klickitat Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the population's health. Indirect take from disease is unknown.

Release:

Hatchery Production/Density-Dependent Effects: It is possible for hatcheries to release numbers of fish that can exceed the density of the natural productivity in a limited area for a short period of time and can compete with listed fish. Fish planted under the proposed program will be made at a fish size, time, and condition factor that will ensure that fish will migrate rapidly from the system, thereby reducing potential competition and predation impacts to listed fish populations. Indirect take from density dependent effects is unknown.

Competition and predation: According to the HSRG (2004), and supported by data presented by Flagg et al. (2000), the potential for predation of wild salmonids by hatchery-reared smolts will depend on the size, number, and spatial distribution of both predators and prey, the functional and numerical responses of the predators, and the amount of time that predators and prey are in proximity. Busack et al. (2005) reviewed published rates of predation by juvenile hatchery salmonids on wild juvenile Chinook and found that predation rates were generally low (<2% of natural population consumed). In contrast, data collected on hatchery coho predation rates on wild fall Chinook juveniles in the Lewis River were quite high (>11%) (Hawkins and Tipping 1999). The variability in study results is one reason that the HSRG (2004) suggests that hatcheries monitor predation impacts resulting from hatchery releases. This type of study is proposed as part of the Klickitat River Anadromous Fisheries Master Plan (Yakama Nation 2008).

In general, hatchery fish can consume fish that are 50% of their body size; however studies reviewed by Busack et al. (2005) indicated that the range may extend from approximately 38% (steelhead) to 75% (coho). NOAA Fisheries and the USFWS in a number of biological assessments and opinions, e.g. USFWS 1994; NMFS 1999, were of the opinion that juvenile salmonids can consume prey at ~33% of their body length. Predation by hatchery fish on wild fish can occur anywhere the two stocks exist in space and time. Therefore, predation may not only be a concern in the stream environment, but also in the estuary and marine environment.

The site-specific nature of predation, and the limited number of empirical studies that have been conducted, make it difficult to predict the predation effects of this specific hatchery release. The YN is unaware of any studies that have empirically estimated the predation risks to listed fish posed by the Klickitat Hatchery programs. In the absence of site-specific empirical information, the identification of risk factors can be a useful tool for reviewing hatchery programs while monitoring and research programs are developed and implemented.

<u>Date of Release:</u> The release date can influence the likelihood that listed species are encountered. The summer steelhead spawning window is from mid-February to mid-May while winter –run spawning occurs early March and lasts to mid-May (Klickitat River Anadromous Fisheries Master Plan *in draft*). Depending on available temperature units, steelhead eggs will hatch in 4-7 weeks with fry emergence approximately 2-3 weeks after hatching. This means that the majority of fry emergence takes place after hatchery smolts have left the Klickitat River system in April/May. Additionally, steelhead fry are found in shallow low velocity stream habitat not generally be accessible to the larger steelhead smolts, thereby reducing encounter rates and predation levels.

<u>Fish Size at Release:</u> Based on the 33% of body length predation assumption put forward by NMFS and USFWS and a steelhead size of release range of 180-220 mm, hatchery steelhead may consume juvenile fish that range in size from 59-73 mm. During the time of release, the majority of steelhead juveniles present in the system are expected to be 1+ smolts that are generally larger than 80 mm. These fish are too large to be consumed by hatchery smolts.

<u>Release Location and Release Type</u>: The likelihood of predation may also be affected by the location and the type of release. Other factors being equal, the risk of predation may increase with the length of time that fish co-mingle. In the freshwater environment, this is likely to be affected by distribution of the listed species in the watershed, the location of the release, and the speed at which fish released from the program migrate. Summer steelhead will be released volitionally from rearing sites located at RKm 68 and RKm 102 (tentative). Dawley

et al. 1984 found that steelhead migrate in the Columbia River at a rate of 35 Rkm per day, which if applicable to the Klickitat would mean that hatchery steelhead require less than 4-days to migrate out of the system. The small amount of time the hatchery fish are present in the Klickitat River should reduce possible competition and predation effects to listed fish species.

Residualism: To maximize smolting characteristics and minimize residualism, the YN adheres to a combination of acclimation, volitional release strategies, size, and time guidelines as developed at the Cle Elum Supplementation and Research Facility (CESRF). These same guidelines will be applied to the summer steelhead program in the Klickitat River. The guidelines include the following:

1. Feeding rates and regimes throughout the rearing cycle are to be programmed to satiation feeding to minimize size variations and re-programmed as needed to achieve goals for smolt size at time of release.

2. Fish Condition factors, standard deviation and co-efficient of variation (CV) on lengths of fish will be collected throughout the rearing cycle. The data are used to ensure that fish growth rates achieve size at release targets, with less than a 10% variation.

3. Releases from the hatchery and acclimation sites are set to mimic wild fish emigration timing.

4. Releases from acclimation ponds will be volitional so that fish not ready to migrate will likely remain in the ponds. This action should reduce competition effects to wild populations.

Migration Corridor/Ocean: The Columbia River hatchery production ceiling, called for in the Proposed Recovery Plan for Snake River Salmon of approximately 197.4 million fish (1994 release levels), has been incorporated by NOAA-Fisheries into their recent hatchery biological opinions to address potential mainstem corridor and ocean effects, as well as other potential ecological effects from hatchery fish. Although hatchery releases occur throughout the year, approximately 80 percent occur from April to June and Columbia River mainstem out-migration occurs primarily from April through August (www.fpc.org). Once in the main stem, Witty et al. (1995) has concluded that predation by hatchery production on wild salmonids does not significantly impact naturally produced fish survival in the Columbia River migration corridor. In a study designed to define the migrational characteristics of Chinook salmon, coho salmon, and steelhead trout in the Columbia River estuary, Dawley et al (1984), found the average migration rates for subyearling Chinook, yearling Chinook, and coho salmon and steelhead, were 22, 18, 17, and 35 RKm/d respectively. There appear to be no studies demonstrating that large numbers of Columbia system smolts emigrating to the ocean affect the survival rates of juveniles in the ocean in part because of the dynamics of fish rearing conditions in the ocean and an inability to measure.

Monitoring:

1) Smolt Monitoring- Smolt traps above Castile Falls, near the Klickitat Hatchery, and lower Klickitat River will be used to monitor hatchery fish migration timing and abundance.
2) Adult trapping at Lyle Falls, Castile Falls, and Klickitat River Hatchery will be monitored for impacts to listed steelhead and bull trout adults.

These activities have the potential to harass, kill, or injure handled fish. For example, smolt monitoring with screw traps in the Klickitat River have resulted in some fish losses over time. Incidental take of steelhead juveniles resulting from Rotary screw trap operations averaged 3.7% of the total number of juveniles handled between 2003 and 2006. Mortality associated with future screw trap operations is not expected to exceed 5% of all wild juvenile steelhead handled.

Incidental mortality associated with adult trapping and broodstock collection is not expected to occur with the infrastructure improvements to the Lyle Falls Fishway and adult trap.

Lyle Falls Juvenile Steelhead Rotary Screw trap handling information for the Klickitat River (2003-2006)

	Workups		Tallies		Grand Totals		
Year	Morts	Total Handled	Morts	Total Handled	Morts	Total Handled	% mortality
2003	8	764	64	515	72	1279	5.6%
2004	1	486	110	2054	111	2540	4.4%
2005	1	379	8	817	9	1196	0.8%
2006	0	81	0	35	0	116	0%
Totals					192	5131	3.7%

* preliminary

Research:
No hatchery research is proposed.

Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

Estimated listed salmonid take levels by hatchery activity.

Steelhead

ESU/Popu	Middle Columbia River Steelhead
Activity	Klickitat Hatchery Spring Chinook Program
Location of hatchery activity	Klickitat R. Hatchery
Dates of activity	May – September
Hatchery Program Operator	WDFW

Type of Take	Annual Take of Listed Fish by life Stage (number of fish)			
	Egg/Fry	Juvenile /Smolt	Adult	Carcass
Observe or harass (a)				
Collect for transport (b)				
Capture, handle, and release (c)		*5,000		
Capture, handle, tag/mark/tissue sample, and release (d)				
Removal (e.g., broodstock) (e)			80	
Intentional lethal take (f)				
Unintentional lethal take (g)				
Other take (indirect, unintentional) (h)				

Past juvenile trapping operations for monitoring purposes not associated with the hatchery have captured ~5,000 steelhead parr and smolts.

** Although steelhead have not been taken during past hatchery practices, it is anticipated that adult steelhead will be collected and handled at the new collection facilities at Lyle Falls and Castile Falls. No or minimal (<1%) mortality is expected from these operations.

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

Program activities will be eliminated or severely curtailed if take levels exceeded those identified for the program. NMFS staff will be notified in writing when take levels are within 95% of those permitted. They will also be notified when take levels have been reached, and the actions that are being implemented to prevent further take of listed species.

Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish.
No wild summer or winter steelhead have been collected at the Klickitat Hatchery. The new program will collect up to 80 natural-origin adults each year.

The following table presents ongoing monitoring activities under the existing YKFP Klickitat Monitoring & Evaluation Project (#1995-063-35), with anticipated ESA take and approach by specific action.

YAKIMA/KLICKITAT FISHERIES PROJECT - KLICKITAT MONITORING AND EVALUATION PROJECT DESCRIPTION

Action	Overview of Action or Purpose	Description	Location	Anticipated Take (per year)					
				General ESA Approach/Notes	Bull Trout adults	Bull Trout juveniles	Steelhead adults	Steelhead juveniles
Spawning ground surveys	Document the abundance and temporal and spatial distribution of spawners and redds in the Klickitat Subbasin for spring Chinook, fall Chinook, coho, and steelhead.	Conduct spawner surveys via wading and/or rafting within the known geographic range in the Klickitat Subbasin. Count individual redds and record location using handheld GPS units. Record counts of live fish and carcasses. Collect biological information from carcasses (length, sex, scale sample, and tag/mark data). Examine carcasses for sex determination, egg/milt retention (percent spawned), and presence of decimal coded wire tags (CWT) tags or external experimental marks. Make attempts to cover the entire known spawning range of each species. Survey each stream reach multiple times (preferably at least 3 survey passes) during the spawning periods.	Throughout Klickitat Subbasin (Klickitat River and anadromous-accessible tributaries); approximately 150 river miles of survey reaches	"Take" for this action may include scaring/stressing fish, temporary moving of fish to other areas, and temporary interruption of spawning. Survey timing is as follows: spring Chinook - mid August through early October; fall Chinook - late October through early to mid December; coho - mid October through mid February; steelhead - late January through early June. No mortalities anticipated.	< 5	< 5	< 100	< 50
Adult salmonid monitoring at Lyle Falls Fishway	Collect data on adult salmonids in the Klickitat River to better understand fish use, run timing, and estimate abundance.	Operate adult trap in the Lyle Falls fishway. Trap will be operated as flows and debris levels allow. Trap will be checked on a regular basis (typically every 24 hours, occasionally longer if fish numbers and water temperatures allow). Biological data will be collected including fish length, tag inspection, scale sample, and DNA samples. Marks (opercle punches and floy tags) will be administered to assist in subsequent resight/recapture and development of population estimates. Fish will be placed in water-filled blackout tubes (PVC tubes with cutout sections) for biological sampling; no anesthesia is used due to harvest availability of fish after leaving trap. Depending on funding, fish may also be PIT-tagged and/or radio-tagged to assist in determination of migration/holding patterns, passage issues, and fishway use. Appropriate anesthesia, ,e.g. CO_2,.will be used.	RM 2.3 on the Klickitat River; T03N, R12E, Sec. 25 NWSW	"Take" for this action includes fish trapping and handling, collection of biological data and marking/tagging. Mortality only occurs on very rare occasions. Trap is operated year round as flows and debris/bedload levels allow.	< 5	0	400-600 Klickitat wild; 50 Snake wild; 400-600 Klickitat hatchery; 50 Snake hatchery; < 2% mortality	0

Action	Overview of Action or Purpose	Description	Location	Anticipated Take (per year)				
				General ESA Approach/Notes	Bull Trout adults	Bull Trout juveniles	Steelhead adults	Steelhead juveniles
Adult salmonid monitoring at Castile Falls fishway	Collect data on adult salmonids in the Klickitat River to better understand fish use, run timing, and estimate abundance	Operate enumeration facility in the Castile Falls fishway. Facility will be operated as flows and debris levels allow. Facility will be checked on a weekly or biweekly basis. Video and PIT tag detection equipment installed in fishway will be primary means of monitoring fish. Occasional trapping and handling of fish will occur for biological sampling purposes (fish length, tag inspection, scale sample, and DNA samples). When operated as a trap, facility will be checked every 24-72 hours depending on fish numbers and water temperatures. Handled fish will be placed in water-filled blackout tubes (PVC tubes with cutout sections) or appropriate anesthesia will be used.	RM 64.6 on the Klickitat River; T09N R13E, Sec. 18 SWSW	"Take" for this action includes occasional fish trapping and handling, collection of biological data and marking/tagging. Mortality will likely occur only on very rare occasions. Facility will be operated year round as flows and debris/bedload levels allow.	0	0	50-200 Klickitat wild; < 2% mortality	0
Juvenile out-migration monitoring	Continuous monitoring of juvenile outmigration in the upper and lower Klickitat River utilizing rotary screw traps. Information to provide an index of number of smolts, parr, and fry starting to make their way out of the Klickitat system.	Operate floating rotary screw traps to monitor juvenile (smolt, parr, and fry) outmigration in the upper and lower Klickitat River. Traps will be fished year round (as flows, debris levels, and hatchery releases allow) at the: 1. Klickitat Hatchery trap, 2.Lyle Falls trap, and 3. seasonally (between May and November) at the Castile Falls trap. Calibration studies (mark-recapture trials) will be conducted to estimate trap efficiency and assist in development of smolt production estimates. Environmental and trap data will be recorded along with bio-data on 10 to 30 of each salmonid species represented. Fish will be anesthetized and sampled for length, weight, scales, and DNA. Additional tags or marks may also be administered (fin clips for mark-recapture efficiency testing and PIT tags). The excess and non-salmonid fish will be tallied by species. Depending on funding, 1 or 2 additional smolt traps or instream PIT tag antennas may temporarily be deployed in selected key tributaries, e.g. White Creek.	Lyle Falls (RM 2.3 on the Klickitat River; T03N,R12E, Sec. 25 NWSW) Klickitat Hatchery (RM 42 on the Klickitat River; T06N R13E, Sec. 4 SWNE) Castile Falls (RM 64 on the Klickitat River; T09N,R13E, Sec.19 NENE	"Take" for this action includes fish trapping and handling, collection of biological data and marking/tagging. Mortality only occurs on rare occasions. Lyle Falls and Klickitat Hatchery traps are operated year round (as flows, debris levels, and hatchery releases allow); Castile Falls trap is operated seasonally (generally May to November)	< 5	< 5	< 5 (kelts)	1500-2500 wild; 2000-3000 hatchery: < 5% mortality

Action	Overview of Action or Purpose	Description	Location	Anticipated Take (per year)				
				General ESA Approach/Notes	Bull Trout adults	Bull Trout juveniles	Steelhead adults	Steelhead juveniles
Juvenile and resident salmonid population surveys	Determine the spatial distribution and relative abundance of salmonids throughout the Subbasin to provide baseline information and to guide hatchery and habitat actions.	Electrofishing surveys will be conducted in selected key tributary and mainstream reaches. Standard depletion estimates to determine abundance will be utilized. Snorkel surveys will also be used in selected reaches. Population surveys may be completed in selected reaches pre and post-habitat improvement actions. The number of sites sampled will be determined by time allotted to other field season activities, e.g. habitat surveys. Fish captured will be anesthetized and sampled for length, weight, scales, and DNA. Depending on funding, additional tags or marks may also be administered, e.g. fin clips and PIT tags for abundance estimation and juvenile outmigration monitoring.	Throughout Klickitat Subbasin; specific locations to be determined	"Take" for this action includes fish capture (via electrofishing), scaring/stressing fish or temporary moving of fish to other areas (during snorkel surveys), handling, and collection of biological data. Mortality only occurs on very rare occasions. Sampling will generally occur in the summer and early fall.	< 5	< 5	< 5	100-500; < 2% mortality
Scale analysis	Scales are taken at traps and from carcasses encountered on spawner surveys as part of a continuous and ongoing sampling routine to determine age and stock composition of juvenile and adult salmonid stocks in the Klickitat Subbasin.	Fish scales are taken at screw traps, at the Lyle and Castile adult traps, and from carcasses encountered on spawning surveys. The majority of the scale reading is done by YKFP M&E staff; some scales may be read by WDFW staff.	Same location as screw traps, adult traps, and spawner surveys (above)	No effect – action is scale reading and analysis;	No effect – action is scale reading and analysis	No effect – action is scale reading and analysis	No effect – action is scale reading and analysis	No effect – action is scale reading and analysis

Action	Overview of Action or Purpose	Description	Location	Anticipated Take (per year)				
				General ESA Approach/Notes	Bull Trout adults	Bull Trout juveniles	Steelhead adults	Steelhead juveniles
Sediment monitoring	Monitor stream sediment loads associated with natural and anthropogenic factors, such as logging, agriculture, and road building, which can increase sediment loads in streams used by all salmonids in the Klickitat Subbasin.	Gravel samples will be collected and analyzed using Washington State DNR Timber, Fish and Wildlife (TFW) monitoring methodology. McNeil gravel core samples will be collected at 10-12 sites and will be sieved to estimate percentage composition of various substrate particle sizes.	Klickitat River between RM 16 and 88; Diamond Fork Cr. between RM 0 and 12; White Cr. RM 9; Tepee Cr. RM 5	"Take" for this action may include scaring/stressing fish, temporary moving of fish to other areas, and minor localized turbidity increases during gravel sampling. Sampling will occur in the fall (October – November). No anticipated mortalities.	0	0	<5	<10
Water quality monitoring	Continue ongoing water quality monitoring at established and selected new sites.	Record water quality measurements on selected tributaries and within selected habitat survey reaches on a seasonal and as-possible basis. Portable field meters will be used to measure and record the following parameters: temperature, dissolved oxygen, pH, conductivity, and turbidity. Data will be recorded at 36-38 locations, approximately 5-8 times per year at each location. Temperature is also continuously monitored via data loggers placed in streams at these locations.	Approximately 38 locations throughout Klickitat Subbasin (Klickitat R. and tributaries)	No effect is anticipated.				
Habitat Surveys	Complete TFW habitat surveys at selected sites. Quantitative habitat data will provide the foundation for decision-making relative to habitat restoration, as well as refining related attributes of the EDT model. Survey data will also assist in effectiveness monitoring of habitat restoration	Collect baseline data on existing habitat conditions throughout the basin. The habitat inventories will be conducted using the Washington State DNR Timber, Fish and Wildlife (TFW) monitoring methodology (modules: Stream Segment Identification, Reference Point Survey, Habitat Unit Survey, and Large Woody Debris Survey). Sites may include previously surveyed sites and/or new sites.	Throughout Klickitat Subbasin; specific locations to be determined	"Take" for this action may include scaring/stressing fish or temporary moving of fish to other areas during habitat survey. Surveys generally occur in late spring and summer. No anticipated mortalities.	0	< 50	0	< 100

Action	Overview of Action or Purpose	Description	Location	Anticipated Take (per year)				
				General ESA Approach/Notes	Bull Trout adults	Bull Trout juveniles	Steelhead adults	Steelhead juveniles
	projects and in other land management planning.							
Genetic data collection, analysis, and synthesis	Provide information on subpopulation structure, geographic variation, and production in order to minimize any effects from hatchery actions.	Genetic samples will be collected from adult salmonids at the Lyle and Castile adult traps, and from juveniles at rotary screw traps. Additional samples may also be collected via stream electrofishing. Samples will be sent to Columbia River Intertribal Fish commission (CRITFC) genetics lab or other genetics labs for analysis. YKFP biologists, in collaboration with CRITFC geneticists, will compile existing data and analyze genetics information.	Same location as screw traps, adult traps, and spawner surveys (above) Other locations to be determined throughout Klickitat Subbasin.	Take for this action includes fish capture and handling (with non-lethal fin clip, fin punch, or opercle punch sampling) during stream electrofishing and adult trap and screw trap operation. No anticipated mortalities.	0	0	0	500-1000

Section 3: Relationship of Program to Other Management Objectives

3.1 Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. *Hood Canal Summer Chum Conservation Initiative*) or other regionally accepted policies (e.g. the *NPPC Annual Production Review* Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.

For ESU-wide hatchery plans, the plant of summer steelhead into the Klickitat River is consistent with:

- 1999 Biological Opinion on Artificial Propagation in the Columbia River Basin (NMFS 1999)
- Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995)
- The *U.S. v. Oregon* Columbia River Fish Management Plan
- Columbia River basin Fish and Wildlife Program (http://www.nwcouncil.org/library/2000/2000-19/Default.htm)
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- Klickitat River Anadromous Fisheries Master Plan (YN 2008 *in draft)*
- Scientific Principles and Recommendations of the HSRG (HSRG 2004)

For statewide hatchery plan and policies, hatchery programs in the Columbia system adhere to a number of guidelines, policies and permit requirements in order to operate. These constraints are designed to limit adverse effects on cultured fish, wild fish, and the environment that might result from hatchery practices. Following is a list of guidelines, policies, and permit requirements that govern YN Columbia hatchery operations for the production of spring Chinook for the Klickitat River:

Genetic Manual and Guidelines for Pacific Salmon Hatcheries in Washington. These guidelines define practices that promote maintenance of genetic variability in propagated salmon. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).

Spawning Guidelines for Washington Department of Fisheries Hatcheries. Assembled to complement the above genetics manual, these guidelines define spawning criteria to be use to maintain genetic variability within the hatchery populations.

Stock Transfer Guidelines. This document provides guidance in determining allowable stocks for release for each hatchery. It is designed to foster development of locally adapted broodstock and to minimize changes in stock characteristics brought on by transfer of non-local salmonids (WDFW 1991).

Fish Health Policy in the Columbia Basin. Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Fish Policy Chapter 5, IHOT 1995).

Hatchery Reform: Principles and Recommendations of the Hatchery Scientific Review Group (HSRG 2004). Provides guidance on how hatcheries can be used to conserve naturally spawning salmon and steelhead populations. Bro

National Pollutant Discharge Elimination System Permit Requirements This permit sets forth allowable discharge criteria for hatchery effluent and defines acceptable practices for hatchery operations to ensure that the quality of receiving waters and ecosystems associated with those waters are not impaired.

3.2 List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

The program described in this HGMP is consistent with the following agreements and plans:

- U.S. vs. Oregon court decision
- Production Advisory Committee (PAC)
- Technical Advisory Committee (TAC)
- Integrated Hatchery Operations Team (IHOT) Operation Plan 1995 Volume III.
- Pacific Northwest Fish Health Protection Committee (PNFHPC, http://www.fws.gov/pnfhpc/)
- In-River Agreements: State, Federal, and Tribal representatives
- Northwest Power Planning Council Sub Basin Plans (NPPC 2004)
- Lower Columbia Fisheries Management and Evaluation Plan (WDFW 2003)
- Lower Columbia Steelhead Conservation Initiative (WJNRC and WDFW 1998)
- Memorandum of Understanding for Joint Operation of the Klickitat Hatchery
- Draft Klickitat Subbasin Recovery Plan for Middle Columbia River Steelhead ESU. (NOAA-Portland 2007)

3.3 Relationship to harvest objectives.

3.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years (1988-99), if available.

The primary purpose of hatchery programs in the Mid-Columbia Management Area (MCMA) is to provide harvest opportunity. All hatchery steelhead released for harvest augmentation are adipose fin-clipped. Presence of an adipose fin allows anglers to easily identify wild fish and limit their handling

The Klickitat summer steelhead harvest is important to the subsistence fishing needs of Yakama tribal members. The *U.S. v. Oregon* management plan stipulates that steelhead harvest shares be based on the aggregate of mainstem and tributary catches by tribal and recreational fisheries and, further, that neither the treaty share nor the non-treaty share shall exceed 50 percent of the aggregate harvestable steelhead. Within this framework, each season's regulations for the Klickitat River are developed through consultation between the Washington Department of Fish and Wildlife and the Yakama Indian Nation. Federal court decisions (U.S. vs. Oregon 1969 and U.S. vs. Washington 1974) ruled that Indian tribes who signed treaties with the federal government in the 1850s have treaty fishing rights to harvest a share (50 percent) of surplus fish resources. The treaty tribes may fish in their usual and accustomed fishing grounds in the Columbia River basin and other Washington waters. These court decisions mandated cooperative fisheries management in a government-to-government relationship between Washington State and the treaty Indian tribes. These decisions also mandate state hatchery facilities to produce fish to ensure harvest opportunities for treaty tribes.

Member tribes of the Columbia River Inter-Tribal Fish Commission may hold fisheries in Drano Lake and White Salmon, Klickitat, Walla Walla and Yakima river watersheds, and the mainstem Columbia River. The WDFW does not regulate these fisheries. Each tribe retains its authority to regulate its fisheries and issues fishery regulations through its respective governing bodies. Tribal staff is represented on the CRFMP Technical Advisory Committee and participate in monitoring activities and data sharing with other parties. The tribes have policy representation in the U.S. vs. Oregon harvest management processes and generally coordinate fisheries with the Columbia River Compact (the Compact).

Selective fisheries were initiated for steelhead in 1986 in the Lower Columbia River tributaries. This regulation requires the release of all wild steelhead. The estimated mortality for wild winter steelhead for these fisheries in lower Columbia River tributaries ranges from 4% to less than 7% per basin depending on the fishing regulations. Harvest rates have been as high as 70% for hatchery steelhead in the Cowlitz River. (See also Section 1.12, above).

Harvest						
	Sport			Tribal		
Year	Hatchery	Wild	Total	Hatchery[2]	Wild[2]	Total
1986-87	1,426	54	1,480	5,107	901	6,008
1987-88	1,480	34	1,514	1,141	201	1,342
1988-89	1,718	0	1,718	1,263	223	1,486
1989-90	833	0	833	536	95	631
1990-91	1,055	0	1,055	1,464	258	1,722
1991-92	823	8	831	1,620	286	1,906
1992-93	1,260	0	1,260	1,033	182	1,215
1993-94	1,211	25	1,236	1,151	203	1,354
1994-95	857	34	891	482	85	567
1995-96	864	9	873	433	76	509
1996-97	608	14	622	241	43	284
1997-98	1,062	18	1,080	455	80	535
1998-99	650	12	662	224	39	263
1999-00	575	28	603	214	0	214
2000-01	1,433	59	1,492	495	67	562
2001-02	3,708	16	3,724	724	55	779
2002-03	3,552	97	3,649	1285	363	1,648

Harvest						
	Sport			Tribal		
Year	Hatchery	Wild	Total	Hatchery[2]	Wild[2]	Total
2003-04	1,673	0	1,673	369	151	520
2004-05	1,658	0	1,658	747	153	900
2005-06[5]	1,115	0	1,115	368	98	466
Avg:	1,378	20	1,398	968	178	1,146

3.4 Relationship to habitat protection and recovery strategies.

The new program will eliminate the practice of importing Skamania Summer Steelhead into the basin. Broodstock will be collected from adult fish returning to the Klickitat River. Using fish locally adapted to the environmental conditions present in the basin are expected to improve survival and reduce genetic risks to listed steelhead.

The program described in this HGMP is consistent with the following habitat and protection strategies:

Klickitat Subbasin Recovery Plan for the Mid Columbia ESU- This plan provides habitat strategies to be used to recover ESA-listed steelhead in the Klickitat Subbasin. The hatchery program has considered current and future habitat conditions in sizing program and defining release locations**.**

Klickitat Watershed Enhancement Project (KWEP) (Conley 2005):
The KWEP is a BPA-funded watershed restoration project implemented by the Yakama Nation Fisheries Program (YNFP). The YNFP is working in coordination with WDFW, Natural Resources Conservation Service (NRCS), and the Central Klickitat Conservation District. The project was proposed under the Northwest Power Planning Council's Fish and Wildlife Program and funded by BPA in 1997. Project restoration activities are prioritized to benefit listed steelhead populations and the habitat they use. A monitoring program has been initiated to document project success and guide future restoration activities. The second phase of the project will use EDT modeling output to guide and prioritization restoration activities.

Subbasin Planning and Salmon Recovery(NPPC 2004 and Yakama Nation 2004):
The current Klickitat program HGMP processes are designed to deal with existing hatchery programs and potential reforms to those programs. A regional sub-basin planning process is a broad-scale initiative that will provide building blocks of recovery plans for listed fish and may well use HGMP alternative ideas on how to utilize hatchery programs to achieve objectives and harvest goals.

Habitat Treatment and Protection:
YN and others are conducting, or have conducted, habitat inventories within the Klickitat Subbasin. Ecosystem Diagnosis and Treatment (EDT) compares habitat today to that of the Subbasin in a historically unmodified state. It creates a model to predict fish population outcomes based on habitat modifications. WDFW is also conducting a Salmon Steelhead Habitat Inventory Assessment

Program (SSHIAP), which documents barriers to fish passage. WDFW's habitat program issues hydraulic permits for construction or modifications to streams and wetlands. This provides habitat protection to riparian areas and actual watercourses within the watershed.

Limiting Factors Analysis:
A WRIA 30 (Klickitat Subbasin) habitat limiting factors report (LFA) has been completed by the Washington State Conservation Commission. This limiting habitat factors analysis was conducted pursuant to RCW 75.46 (Salmon Recovery). The purpose of this analysis was "to identify the limiting factors for salmonids" where limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon." It was intended that a locally based habitat project selection committee use the findings of this analysis to prioritize appropriate projects for funding under the state salmon recovery program. This analysis may also be used by local organizations and individuals interested in habitat restoration to identify such projects (Washington State Conservation Commission 1999).

The Strategic Plan For Salmon Recovery (HB 2496): Klickitat County functions as the lead entity for this plan which includes Klickitat River and major creeks, Big White Salmon and Little White Salmon. This document provides the prioritized actions addressing limiting factors from which the Salmon Recovery Funding Board projects are ranked for consistency and effectiveness.

3.5 Ecological interactions.

Below are discussions on both negative and positive impacts relative to the Klickitat River summer steelhead outplant program.

(1) Salmonid and non-salmonid fishes or species that could negatively impact the program: Klickitat summer steelhead smolts can be preyed upon through the entire migration corridor extending from the Subbasin to the mainstem Columbia River and estuary. Northern pikeminnows and introduced spiny rays, as well as avian predators, including gulls, mergansers, cormorants, belted kingfishers, great blue herons and night herons, in the Columbia mainstem and sloughs can prey on steelhead smolts . Mammals that can take a heavy toll on migrating smolts and/or returning adults include harbor seals, sea lions, river otters, and orcas.

(2) Salmonid and non-salmonid fishes or species that could be negatively impacted by the program: Natural salmon and steelhead populations that inhabit local tributaries and the Columbia River mainstem corridor areas could be negatively impacted by program fish. Of primary concern are the ESA-listed endangered and threatened salmonids: Snake River fall-run Chinook salmon ESU (threatened); Snake River spring/summer-run Chinook salmon ESU (threatened); Lower Columbia River Chinook salmon ESU (threatened); Upper Columbia River spring-run Chinook salmon ESU (endangered); Columbia River chum salmon ESU (threatened); Snake River sockeye salmon ESU (endangered); Upper Columbia River steelhead ESU (endangered); Snake River Basin steelhead ESU (threatened); Lower Columbia River steelhead ESU (threatened); Middle Columbia River steelhead ESU (threatened); and the Columbia River distinct population segment of bull trout (threatened). Listed fish

can be impacted through a complex web of short- and long-term processes and over multiple time periods which makes evaluation of the net effect difficult.

3) Salmonid and non-salmonid fishes or other species that could positively impact the program. Fall and spring Chinook and coho are released to the Klickitat Subbasin. The Subbasin also supports limited natural production of Chinook, coho, chum, and steelhead as well as non-salmonid fishes (sculpins, lampreys, suckers, etc.). These species may serve as prey items during the emigration through the Subbasin. While not always desired from a production standpoint, the hatchery fish provide an additional food source for natural predators that might otherwise consume listed fish. Hatchery fish may be so numerous that predators consume them in greater numbers resulting in less predation on wild fish.

4) Salmonid and non-salmonid fishes or species that could be positively impacted by the program. Aquatic and terrestrial species that consume salmonids will benefit from the continued release of fish from this program. Common species that may benefit include northern pikeminnow, smallmouth and largemouth bass, gulls, mergansers, cormorants, belted kingfishers, great blue herons and night herons, harbor seals, sea lions, river otters, bear, and killer whales (orcas). Additionally, salmon carcasses act as a source of fertilizer that positively impact riparian plants and also provide nutrients back to the stream.

Section 4. Water Source

4.1 Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile and natural limitations to production attributable to the water source.

Spring water from Indian Ford A Springs and gravity-intake-fed river water supply most of the water for this program, although there are several non-fish bearing streams near the grounds that could be used. Indian Ford Springs provide up to 7,000 gpm of good quality water at 48 –52 degrees F. The river intake supplies up to 7,000 gpm of river water. River pumps that are currently not in use (since 2001) can provide up to 4,000 gpm surface water. Spring water is used for the incubation and early rearing of all juveniles. In late summer, river water is introduced for fish acclimation to Pond 25, located across the river from the hatchery. Fish can be reared in Pond 26, which is supplied with spring water from Wonder Springs, approximately one-half mile downstream and across the river from the main hatchery. Pond 24, located below the fish ladder is also used for fish acclimation and is supplied by both spring and re-use water from hatchery raceway banks.

The acclimation sites at McCreedy Creek (if built) will use water from the stream for rearing. All intakes structures will be screened according to NMFS criteria. Stream temperatures will fluctuate with the natural temperatures in McCreedy Creek; which is dominated by spring water.

4.2 Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

Potential Hazard	Risk Aversion Measure
Hatchery water withdrawal	Water rights total 6000 – 8000 gpm from the gravity intake with another 4,000 pumped from the river. Water rights are formalized through trust water right from the Department of Ecology. Monitoring and measurement of water usage is reported in monthly NPDES reports.
McCreedy Creek Acclimation	The water intake at this facility will be screened according to NMFS standards. Water will only be diverted from the creek for 6 weeks each spring.
Intake/Screening Compliance	Intake structures were designed and constructed to specifications at the time the Klickitat facility was constructed. The Mitchell Act Intake and Screening Assessment (2002) has identified design and alternatives needed to get existing structures in compliant including intake screens and velocity sweeps which are not in compliant with NOAA fish screening standards. From the assessment, YN has been requesting funding for future scoping, design, and construction work of a new intake system.
Hatchery effluent discharges. (Clean Water Act)	This facility operates under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). WAG 13-5002. Monthly

	and annual reports on water quality sampling, use of chemicals at this facility, compliance records are available from DOE. Discharges from the cleaning treatment system are monitored as follows: *Total Suspended Solids (TSS)* C1 to 2 times per month on composite effluent, maximum effluent and influent samples. *Settleable Solids (SS)* 1 to 2 times per week on effluent and influent samples. *In-hatchery Water Temperature* - daily maximum and minimum readings.

Section 5. Facilities

5.1 Broodstock collection facilities (or methods).

Broodstock will be collected at Lyle Falls, Castile Falls, and the Klickitat Hatchery.

5.2 Fish transportation equipment (description of pen, tank, truck, or container used).

Adult steelhead will be trucked for less than 1 hour to spawning facilities located at the Klickitat Hatchery. Fish will be trucked using guidelines described in Hager and Costello (1999).

5.3 Broodstock holding and spawning facilities.

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Available Flow (gpm)
4	Fiberglass	1.570		16	5	100-200

5.4 Incubation facilities.

Incubator Type	Units (number)	Flow (gpm)	Volume (cu.ft.)	Loading-Eyeing (eggs/unit)	Loading-Hatching (eggs/unit)
FAL	168	96	NA	8000-10000	8000-10000

5.5 Rearing facilities.

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Flow (gpm)	Max. Flow Index	Max. Density Index
6	Concrete	3500	100	10	3.5	300-350	1.85	0.2
6	Intermediate Rearing Troughs	87	17	3.3	2	25	NA	0.4

5.6 Acclimation/release facilities.

If natural re-colonization of habitat above Castile Falls by adult steelhead is unsuccessful, new acclimation facilities will be constructed at McCreedy Creek. The site will consist of two 0.4 acre ponds with intake and outlet structures.

5.7 Describe operational difficulties or disasters that led to significant fish mortality.

No significant fish losses have occurred at the Klickitat Hatchery for any species.

5.8 Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

Potential Hazard	Risk Aversion Measure
Equipment failure and/or water loss	Multiple water sources are available. There is a main river gravity water feed system, three torpedo type river pumps, and several springs available. Backup generator system is automatic in case of power loss.
Flooding/Water Loss	The facility is sited to minimize the risk of catastrophic fish loss from flooding and equipped with low water alarm probes in strategic locations to prevent loss of fish due to loss of water. Alarm systems are monitored 24/7 with staff available on-station to respond to problems. McCreedy Creek facility could be temporarily impacted by 100-year flood events. Fish in this facility would be released into the stream environment during such an event.
Disease Transmission	IHOT fish health guidelines are followed. Fish Health Specialists conduct inspections monthly and problems are managed promptly to limit mortality and reduce possible disease transmission.

Section 6. Broodstock Origin and Identity

6.1 Source.

The stock native to the Klickitat River will be used for broodstock.

6.2.1 History.

New program, therefore not applicable. Historically, out-of-subbasin Skamania stock were used to provide fish for harvest in the Subbasin. This program will be phased out with the implementation of the new native program.

6.2.2 Annual size.

Annual broodstock need will be approximately 70-80 NOR adults. This constitutes roughly 5%-10% percent of total summer steelhead escapement to the basin. Broodstock will be collected based on a 1:1 male to female ratio.

6.2.3 Past and proposed level of natural fish in the broodstock.

The new program will use 100% NOR adults. The old program used out-of-basin Skamania stock and no natural fish (from the Klickitat River) were ever used as broodstock.

6.2.4 Genetic or ecological differences.

The program will use native broodstock, therefore no differences are expected.

6.2.5 Reasons for choosing.

Using native stock will ensure that the broodstock has the traits needed to thrive in the Klickitat River.

6.3 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices.

DNA samples will be collected from both the natural and hatchery components to determine if genetic divergence is occurring over time. Information on run-timing, age and sex composition will also be collected. On a 5-year cycle, DNA samples will be collected from wild juvenile steelhead in key tributaries. Adults will be collected randomly throughout the full run-timing of the species.

Section 7. Broodstock Collection

7.1 Life-history stage to be collected (adults, eggs, or juveniles).

Adults

7.2 Collection or sampling design

Adults will be collected at random throughout the full migration period for summer steelhead. Winter steelhead will not be used as broodstock.

7.3 Identity.

Collection of summer steelhead will not be collected during periods when winter steelhead are migrating past Lyle Falls. Real-time DNA samples will be collected on all fish used for broodstock to ensure that only native Klickitat River summer steelhead are collected (Klickitat River Anadromous Fisheries Master Plan *in draft*). Collected adults not used for broodstock will be returned unharmed to the stream.

7.4 Proposed number to be collected:

7.4.1 Program goal (assuming 1:1 sex ratio for adults):

70-80 NOR adults

7.4.2 Broodstock collection levels for the last twelve years (e.g. 1990-2001), or for most recent years available.

Not Applicable; this is a new program. Historically, Skamania summer steelhead were used as broodstock.

7.5 Disposition of hatchery-origin fish collected in surplus of broodstock needs.

All surplus HOR fish returning to the Klickitat Hatchery will be distributed to tribal members for ceremonial and subsistence purposes.

7.6 Fish transportation and holding methods.

Fish will be handled and transported as defined in Hager and Costello (1999). Fish will be anesthetized with carbon dioxide gas in a water solution prior to handling, and an aqua-slime agent will be added to transport water. The anesthetized fish are loaded into a portable fish transportation tank where they revive from the CO_2. Fish will be in the transport system for less than 1 hour.

7.7 Describe fish health maintenance and sanitation procedures applied.

Adults transported to hatchery will begin receiving regular treatments of a formalin solution to either prevent or control fungal infection. Adults will be held in cold, spring water to help minimize disease problems.

Once fish are transferred to the adult holding ponds, they will receive regular treatments with a formalin solution to prevent fungal infection. The fish will be held in cold spring water, which helps to prevent disease or parasite problems.

The spawning area and equipment are routinely disinfected with an iodine solution to prevent disease outbreaks. "Green" eggs are water-hardened in an iodine solution to prevent disease or viral contamination. Ovarian fluid and sperm samples are collected and cultured for IHN virus

7.8 Disposition of carcasses.

NOR adult broodstock will be live-spawned and the adults PIT-tagged (upon collection at Lyle Falls or Castile Falls) and returned to the river. Adult carcasses (if any) will be disposed of in an upland landfill.

7.9 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program.

- NOR adults will be collected at random throughout the run at large to ensure the full range of life history traits are incorporated into the hatchery.
- A 1:1 sex ratio is the target for broodstock spawning.
- NOR adults will be live-spawned and released to the stream.

Section 8. Mating

8.1 Selection method.

Broodstock is collected from wild summer steelhead from throughout the run. Program targets are: 1) fish are paired at random from ripe fish, 2) fish are live-spawned with a single other individual, and 3) fish are spawned only once.

8.2 Males.

Backup males will be collected and used to ensure the availability of ripe males to spawn with ripe females throughout the spawning period. Repeat spawners will be included proportionally to the observed age structures and the probability of random collection throughout the run-timing period. Scale samples will be collected on all broodstock to determine if repeat spawners are present.

The target sex ratio for this program is 1:1, although the actual ratio may vary. This is a new program with initial uncertainty at start.

8.3 Fertilization.

The steelhead protocols include the goal of 1:1 sex ratios (one male/one female family units), and whenever possible a 2x2 factorial mating will be utilized. Adult females will be live spawn by use of air injection. Gametes may be pooled, but only after the results of the IHN viral sampling verifies negative results.

Prior to spawning, anesthetized adults are dried and wiped down with an iodine solution. Ovarian fluid and sperm samples are collected during spawning and later analyzed for the presence of IHN virus. “Green” eggs are water-hardened in an iodine antiseptic solution. The eggs are rinsed and treated with another iodine solution bath prior to initiation of the incubation process. Eggs will be incubated in an incubation building separate from salmon facilities. Quarantine methodology will be adapted to prevent the spreading of pathogens.

8.4 Cryo-preserved gametes.

Cryo-preserved gametes will not be used

8.5 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

Broodstock are selected at random from throughout the wild summer steelhead run. Spawning is done randomly based on availability of ripe fish. Matings are done on a 1:1 sex ratio, i.e. one male and one female. Factorial matings of 2x2 crosses will be utilized to prevent genetic population impacts. DNA samples will be collected from both the natural and hatchery components of the run to track to detect changes in allele frequency or presence.

Section 9. Incubation and Rearing.

9.1.1 Number of eggs taken and survival rates to eye-up and/or ponding.

The program will collect approximately 152,000 eggs from NOR adults. This value may change as more is learned about egg-to-smolt survival rates for the native fish population.

9.1.2 Cause for, and disposition of surplus egg takes.

Variability in fecundity and egg survival rates may result in surplus egg take. Surplus eggs from NOR adults will be reared and incorporated into the on-station release.

9.1.3 Loading densities applied during incubation.

Eggs will be incubated in vertical stack incubators supplied with cold spring water at a constant temperature of 48-50 degree Fahrenheit. After IHN viral screening is completed, eggs will be pooled into 10,000 egg/tray loadings with “vexar” substrate.

9.1.4 Incubation conditions.

Eggs will be pooled into 10,000 egg/tray loadings. Egg development will be tracked daily by use of temperature unit monitoring. Eggs will be treated daily until hatching with a 1:600 formalin flow through treatment to prevent fungal infection. Upon hatching (500+ temperature units) and egg yolk absorption, fry will be removed from incubators and placed into intermediate rearing troughs for initial feeding. Temperature units for fry at the time of ponding will be ~1000 TU.

9.1.5 Ponding.

Fry will be initially reared in intermediate troughs. Fry are to be inspected daily beginning at 950 TU, and will be ponded when an estimated 90% of the fry are buttoned up. Ponding is forced, swim up is volitional, and feeding will begin when an estimated 90% of the fry have surfaced in the pond. When fry densities approach loading limits within intermediate trough confines, then these populations will be transferred to raceways for juvenile rearing.

9.1.6 Fish health maintenance and monitoring.

Staff will conduct daily inspection, visual monitoring and sampling from eye, fry fingerling and sub-yearling stages. As soon as potential problems are seen, these concerns will be immediately communicated to the fish health specialist. In addition fish health specialists will conduct inspections monthly. Potential problems are to be managed promptly to limit mortality and reduce possible disease transmission. Formalin (37% formaldehyde) will be dispensed into water for control of ecto-parasites on juvenile fish and for fungus control on eggs.

The steelhead incubation, rearing, and adult holding areas are to be contained in a quarantine area. Disinfection protocols apply in the form of iodophore foot baths at incubation entrances, separate tools and equipment from Chinook operations.

9.2.1 Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years (1990-2001), or for years dependable data are available.

Not Applicable- New program using a different source of fish.

9.2.2 Density and loading criteria (goals and actual levels).

Steelhead densities in the intermediate troughs will be kept below 2 pounds of fish per gpm inflow, and 1 pound per cubic foot of water volume. Steelhead transferred to 100 foot raceways will be kept at densities below 10 pounds of fish per gpm inflow and 1 pound per cubic foot of volume. All the water used in the various containers for the steelhead initial rearing (including incubation & adult ponds) is single use water with no re-use. Some re-use water may be used for juvenile rearing in raceways.

9.2.3 Fish rearing conditions.

Influent and effluent water will be monitored per NPDES fin-fish rearing regulations. Flow index and loadings will be monitored throughout early, juvenile and smolt acclimation rearing periods.

9.2.4 Indicate biweekly or monthly fish growth information (average program performance), including length, weight, and condition factor data collected during rearing, if available.

Not available as this is a new program. Fish growth rates will be designed to achieve a release size of 6-8 fpp in late April.

9.2.5 Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available.

Not available

9.2.6 Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Rearing Period	Food Type	Application Schedule (#feedings/day)	Feeding Rate Range (%B.W./day)	Lbs. Fed Per gpm of Inflow	Food Conversion During Period
May-July	Ewos Micro#1&2	8	2.0	0.003	0.5
August-September	Ewos Pacific 1.2mm	2	1.75	0.02	0.60
October-December	Ewos Pacific 1.5mm	2	0.9-1.25	0.03	1.0
January-April	Ewos Pacific 1.5mm	2	.9	0..057	1.0

9.2.7 Fish health monitoring, disease treatment, and sanitation procedures.

Monitoring	A fish health specialist inspects fish monthly at Klickitat Hatchery and checks both healthy and any symptomatic fish. Based on pathological or visual signs by the crew, age of fish and the history of the facility, the pathologist determines the appropriate tests. External signs such as lesions, discolorations, and fungal growths will lead to internal examinations of skin, gills, and organs. Kidney and spleen are checked for bacterial kidney disease (BKD). Blood is checked for signs of anemia or other pathogens. Additional tests for virus or parasites are done if warranted.
Disease Treatment	Bacterial cold water disease (Flavobacteriosis) can occur mid-summer with Florfenicol used to control. IHN can occur from mid-summer to fall. Loss of fish to IHN in 2002 at the Klickitat Hatchery was 6% of the summer steelhead population (Skamania). As needed, appropriate therapeutic treatment will be prescribed to control and prevent further outbreaks. Mortality is collected and disposed of at a landfill. Fish health and or treatment reports are kept on file.
Sanitation	All eggs brought to the facility are surface-disinfected with iodophore (as per disease policy). All equipment (nets, tanks, boots, etc.) is disinfected with iodophore between different fish/egg lots. Different fish/egg lots are physically isolated from each other by separate ponds or incubation

	units. The intent of these activities is to prevent the horizontal spread of pathogens by splashing water. Tank trucks are disinfected between the hauling of adult and juvenile fish. Foot baths containing disinfectant are strategically located on the hatchery grounds to prevent spread of pathogens.

9.2.8 Smolt development indices (e.g. gill ATPase activity), if applicable.

ATPase data will be collected to determine smoltification levels prior to release. Hatchery staff will also look for behavioral clues such as swarming, and fish jumping at screens.

9.2.9 Indicate the use of "natural" rearing methods as applied in the program.

None.

9.2.10 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to <u>listed</u> fish under propagation (Rearing).

- Monitor and implement feeding and growth regimes that reduce incidence of residualism and maximize smoltification.
- Steelhead Rearing Guidelines target release sizes and condition factors that result in actively migrating smolts that vacate the system and limit freshwater interactions with listed species.
- Reared steelhead smolts will come from summer steelhead parents collected throughout the run. Steelhead smolts will be acclimated in large ponds at the hatchery. The ponds will be equipped with natural cover, and camouflaged pond bottoms.
- Fish will migrate volitionally from acclimation ponds upon release.

Section 10. Release

10.1 Proposed fish release levels.

The initial release level is 130,000 smolts. If native adult steelhead are unable to colonize habitat upstream of Castile Falls, an additional 70,000 smolts may released.

10.2 Specific location(s) of proposed release(s).

Klickitat Hatchery (RKm 68) and McCreedy Acclimation Facility (RKm 113)

10.3 Actual numbers and sizes of fish released by age class through the program.

Initial releases will consist of 130,000 yearling smolts at 6-8 fpp.

10.4 Actual dates of release and description of release protocols.

Fish will be released volitionally from both rearing sites. Fish are expected to migrate from April through Mid-June depending on water temperature.

Klickitat Hatchery – April 1- May 1
McCreedy Creek – April 15 –June 15 (if implemented)

10.5 Fish transportation procedures, if applicable.

The McCreedy Creek release group (if implemented) will be transported to acclimation facilities 6-weeks prior to the target release date. Standard transport procedures will be followed (Hager and Costello 1999).

On-station releases will not need to be transported as all rearing activities occur in a single location.

10.6 Acclimation procedures (*methods applied and length of time*).

See 10.5.

10.7 Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.

The on-station release will be 100% ad-clipped. A sub-sample of each group will also be PIT-tagged to determine survival and harvest rates, as well as migration return timing at Lyle Falls and the Klickitat Hatchery.

If the McCreedy Creek facility is built, it release group of 70,000 will be 100% elastomer tagged.

10.8 Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

All surplus hatchery-reared juveniles with NOR parents will be released.

10.9 Fish health certification procedures applied pre-release.

Prior to plants or releases, the population health and condition is established by the USFWS Fish Health Specialist. This is commonly done 1-3 weeks pre-release or up to 6 weeks before on systems with pathogen-free water and little or no history of disease. Prior to this examination, staff will contact the USFWS Fish Health Specialist if abnormal behavior or mortality is observed,. The fish health specialist will examine affected fish and will recommend the appropriate treatment. Reporting and control of selected fish pathogens are done in accordance with the Yakama Nation and IHOT guidelines.

10.10 Emergency release procedures in response to flooding or water system failure.

Rearing ponds on station are above the 100-year floodplain. The facility also has a backup water supply (secondary reuse water) that can be tapped in an emergency.

Fish in the McCreedy Creek acclimation ponds will be released if water intakes fail, or ponds are likely to be flooded.

10.11 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases.

- Fish will be released volitionally to ensure rapid migration through the system. This will reduce competition and predation effects on listed steelhead and bull trout.
- Fish that do not migrate volitionally from the hatchery or acclimation ponds will not be released, but instead will be transferred and released into landlocked lakes to support local fisheries.

Section 11. Monitoring and Evaluation of Performance Indicators

11.1.1 Describe plans and methods proposed to collect data necessary to respond to each "Performance Indicator" identified for the program.

A proportion of each release group will be PIT-tagged for the purpose of monitoring smolt to adult survival performance indicator (2%) and any differential survival between the release groups. Results from the survival analysis will be used to make changes to hatchery operations if needed.

The composite hatchery and natural population will be managed for a Proportion of Natural Influence (PNI) by using 100% NOR broodstock for the juvenile release program and by controlling the number of hatchery fish present on the spawning grounds. The overall objective is to achieve a PNI of greater than 0.67.

Actions proposed to reduce the proportion of hatchery steelhead adults present on the spawning grounds include maintaining high harvest rates and removing hatchery steelhead at Lyle Falls and Castile Falls. Terminal fisheries are expected to sufficiently remove adequate numbers of HORs as harvest rates have averaged about 88% over the last 10 years. In years with strong hatchery returns, additional harvest will be encouraged by increasing daily bag limits for adult hatchery-origin steelhead. Additionally 80-90% of the returning HORs from the Klickitat Hatchery release group not caught in fisheries are expected to volunteer back to the hatchery due to the unique signature from the spring water used for acclimation.

Contribution to fisheries will be monitored by both Tribal and WDFW biologists through currently existing creel survey protocols.

11.1.2 Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Upon adoption of the Klickitat River Anadromous Fisheries Master Plan, the combination of BPA and Mitchell Act funds will be sufficient to conduct needed M&E.

11.2 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to <u>listed</u> fish resulting from monitoring and evaluation activities.

Monitoring, evaluation, and research follow scientific protocols and will employ the adaptive management process, as needed. YN will take risk aversion measures to eliminate or reduce ecological effects, injury, or mortality as a result of monitoring activities. Most trap mortalities are the result of equipment failure or extreme environmental conditions that flood traps. YN will take precautions to make sure the equipment is properly functioning during the season. If environmental conditions are forecast that will cause high mortality, then traps will be removed or opened up to allow unobstructed passage without mortality. Any take associated with monitoring activities is unknown but all follow scientific protocols designed to minimize impact.

Section 12. Research

12.1 Objective or purpose.

None Proposed

12.2 Cooperating and funding agencies.

12.3 Principle investigator or project supervisor and staff.

12.4 Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2.

12.5 Techniques: include capture methods, drugs, samples collected, tags applied.

12.6 Dates or time periods in which research activity occurs.

12.7 Care and maintenance of live fish or eggs, holding duration, transport methods.

12.8 Expected type and effects of take and potential for injury or mortality.

12.9 Level of take of listed fish: number of range or fish handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached "take table" (Table 1).

12.10 Alternative methods to achieve project objects.

12.11 List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

12.12 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury or mortality to listed fish as a result of the proposed research activities.

Section 13. Attachments and Citations

13.1 Attachments and Citations

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NOAA 2005. Updated Status of Federally Listed ESU's of West Coast Salmon and Steelhead. NOAA Technical Memorandum NMFS-NWFSC-66.

NPPC 2004. Klickitat Subbasin Plan. Prepared for the Northwest Power and Conservation Council. Prepared by the Yakama Nation, Klickitat County, and Washington Department of Fish and Wildlife.

WDFW and NWIFC 1998. Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Prepared by the Washington Department of Fish and Wildlife and The Northwest Indian Fisheries Commission.

USFWS (U.S. Fish and Wildlife Service). 1994. Biological assessment for operation of U.S. Fish and Wildlife Service operated or funded hatcheries in the Columbia River Basin in 1995-1998. Submitted to National Marine Fisheries Service (NMFS) under cover letter, dated August 2, 1994, from William F. Shake, Acting USFWS Regional Director, to Brian Brown, NMFS.

Washington Department of Fisheries. 1991. Stock Transfer Guidelines. Hatcheries Program, Washington Department of Fisheries. Olympia, WA.

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Witty, K., C. Willis and S. Cramer. 1995. A review of potential impacts of hatchery fish on naturally produced salmonids in the migration corridor of the Snake and Columbia Rivers. S.P. Cramer and Associates, Inc, Gresham, OR.

Yakama Nation 2004. Klickitat Subbasin Supplement. Prepared for the Northwest Power and Conservation Council. Prepared by the Yakama Nation.

Yakama Nation 2008. *Draft* Klickitat River Anadromous Fisheries Master Plan. Yakima/Klickitat Fisheries Program, Toppenish, WA.

Section 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

14.1 Certification Language and Signature of Responsible Party

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by_____________________________ Date:_____________

Section 15

ADDENDUM A. PROGRAM EFFECTS ON OTHER (AQUATIC OR TERRESTRIAL) ESA-LISTED POPULATIONS

15.1) List all ESA permits or authorizations for USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species associated with the hatchery program.

No permits in place for this new program. They will be developed through consultation with appropriate agencies as facilities and programs are developed**.**

15.2) Describe USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species and habitat that may be affected by hatchery program.

Hatchery operations may impact USFWS listed Klickitat River bull trout (*Salvelinus confluentus*). Bull trout are listed as Threatened by the USFWS. The USFWS has designated the West Fork Klickitat River and Klickitat River reaches adjacent to the Yakama Indian Reservation as Critical Habitat (Federal Register 2005). Stream habitat in the Klickitat River Subbasin has been impacted by human activities associated with agriculture, logging, recreation, and urban development.

Hatchery facilities are located both within and near the Klickitat River. Water for rearing anadromous fish at the Klickitat River hatchery is diverted from the river. New juvenile acclimation sites are being developed at the Wahkiacus Hatchery (RKm 27) that will disturb upland and riparian habitat near the stream channel. A diversion structure will also be built at this facility to provide water for acclimating hatchery smolts.

Other listed or candidate species that may be impacted by the construction and operation of the Wahkiacus Hatchery and Acclimation Facility Creek include:

Oregon Spotted Frog (*Rana pretiosa)*-	Candidate
Bald Eagle (*Haliaeetus leucocephalus)* -	Threatened
Northern Spotted Owl (*Strix occidentalis)* –	Threatened

The possible impact the construction of new facilities or operation of these facilities may have on these species has not been quantified.

15.3) <u>Analyze effects.</u>

<u>Bull Trout</u>

Possible hatchery operational effects to listed bull trout in the Klickitat River are described below. The effects are expected to be on-going while the hatchery program remains in place.

Water diversion: Water is diverted from the stream for hatchery operations. This results in a decrease in the amount and quality of habitat for approximately 0.25 mile. The loss in habitat may result in a decrease in steelhead and bull trout abundance although the loss has not been quantified. In addition, The Mitchell Act Intake and Screening Assessment (2002) has identified design and alternatives needed to get existing structures in compliance with NOAA fish screening standards. From the assessment, YN has been requesting funding for future scoping, design, and construction work of a new intake system at the Klickitat Hatchery.

Waste and Pollutants: All hatchery facilities will under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). The limitations listed in the permit are assumed to be protective of water quality and therefore the hatchery waste water is likely to have little impact on bull trout.

Disease: Outbreaks in the hatchery may cause significant adult, egg, or juvenile mortality. Over the years, rearing densities, disease prevention and fish health monitoring have greatly improved the health of the programs at Klickitat Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1994) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the populations’ health. The level of indirect take of bull trout from disease is unknown.

Broodstock Collection: Bull trout adults may be handled at steelhead adult collection systems located at Lyle Falls and Castile Falls. Because facilities will be designed to NMFS standards, little impact (injury or loss) to bull trout is expected from their operation

Acclimation Facilities: New acclimation facilities are likely to be constructed in the upper Subbasin at McCreedy Creek. Migratory adult and juvenile bull trout may be affected by facility operations or fish releases from this facility.

Release of Juveniles: The program will release 130,000 summer steelhead into the Klickitat River each year. These fish may compete with and prey on juvenile bull trout. Smolt length at release will range from 145-180 mm. If it assumed that steelhead of this size can consume fish up to 33% of their body length, there is the possibility that bull trout less than 59 mm may be susceptible to predation. Because hatchery summer steelhead will not be released in the primary bull trout stream (West Fork Klickitat River), it is unlikely that the hatchery smolts will prey on, or compete with, listed bull trout.

Food: The carcasses of summer steelhead adults that spawn naturally in the Subbasin may increase stream productivity through the addition of ocean-derived nutrients.

Increased productivity may result in an increase in food availability to both juvenile and adult bull trout. Offspring of naturally spawning coho may also provide a food source for bull trout.

Monitoring and Evaluation: Smolt trapping may be used to determine that hatchery summer steelhead juveniles migrate quickly through the system after release. Some bull trout may be captured and handled at the trapping facilities.

Oregon Spotted Frog

Neither the hatchery operations nor the proposed new facilities are likely to adversely impact this species. The only known population of Oregon Spotted Frog in the Klickitat River Subbasin is located in the Conboy Lake National Wildlife Refuge (NWR) managed by USFWS (NPPC 2004). The refuge is located approximately 10 miles east of Trout Lake and 7 miles southwest of Glenwood in the Glenwood Valley/Camas Prairie area.

Bald Eagle

Bald eagles can be found throughout the year in the Klickitat River Subbasin. Because this species feeds on salmon, hatchery production should result in an increase in food for this species as more adult fish return to the Subbasin. Hatchery activities such as fish transport and the operation of the McCreedy Creek Acclimation Facility may result in the harassment of this species, but the effect is expected to be short-term and minor in nature.

Northern Spotted Owl

No facilities will be located in nor activities conducted in areas inhabited by the Northern Spotted Owl or in suitable owl habitat.

15.4) Actions taken to minimize potential effects.

Bull trout

Diversion Screens: All intake screens will be built or updated to meet NMFS screen criteria for fry.

Waste and Pollutants: All terms and conditions associated with the NPDES Permit will be implemented and followed.

Broodstock Collection: Any bull trout collected as part of hatchery operations will be returned unharmed to the stream.

Acclimation Facilities: These facilities will be sited so as to reduce impacts to riparian and stream habitats to the extent possible. The YN will coordinate the location and construction of this facility with USFWS staff to minimize or avoid impacts to all listed species.

Monitoring and Evaluation: Bull trout collected during juvenile trapping operations will be released unharmed to the stream.

Oregon Spotted Frog

Prior to constructing acclimation facilities in McCreedy Creek, the stream and riparian area near proposed sites will be surveyed for species presence. If this species is found, the YN will coordinate with USFWS staff to develop mitigation and protection measures. This activity will be covered through the EIS needed for implementation of the 2008 Draft Klickitat River Anadromous Fisheries Master Plan

Bald Eagle

Acclimation facilities will not be located near bald eagle nests.

Northern Spotted Owl

The acclimation facility is not located in Northern Spotted Owl habitat; no adverse impacts are expected to this species.

15.5) References

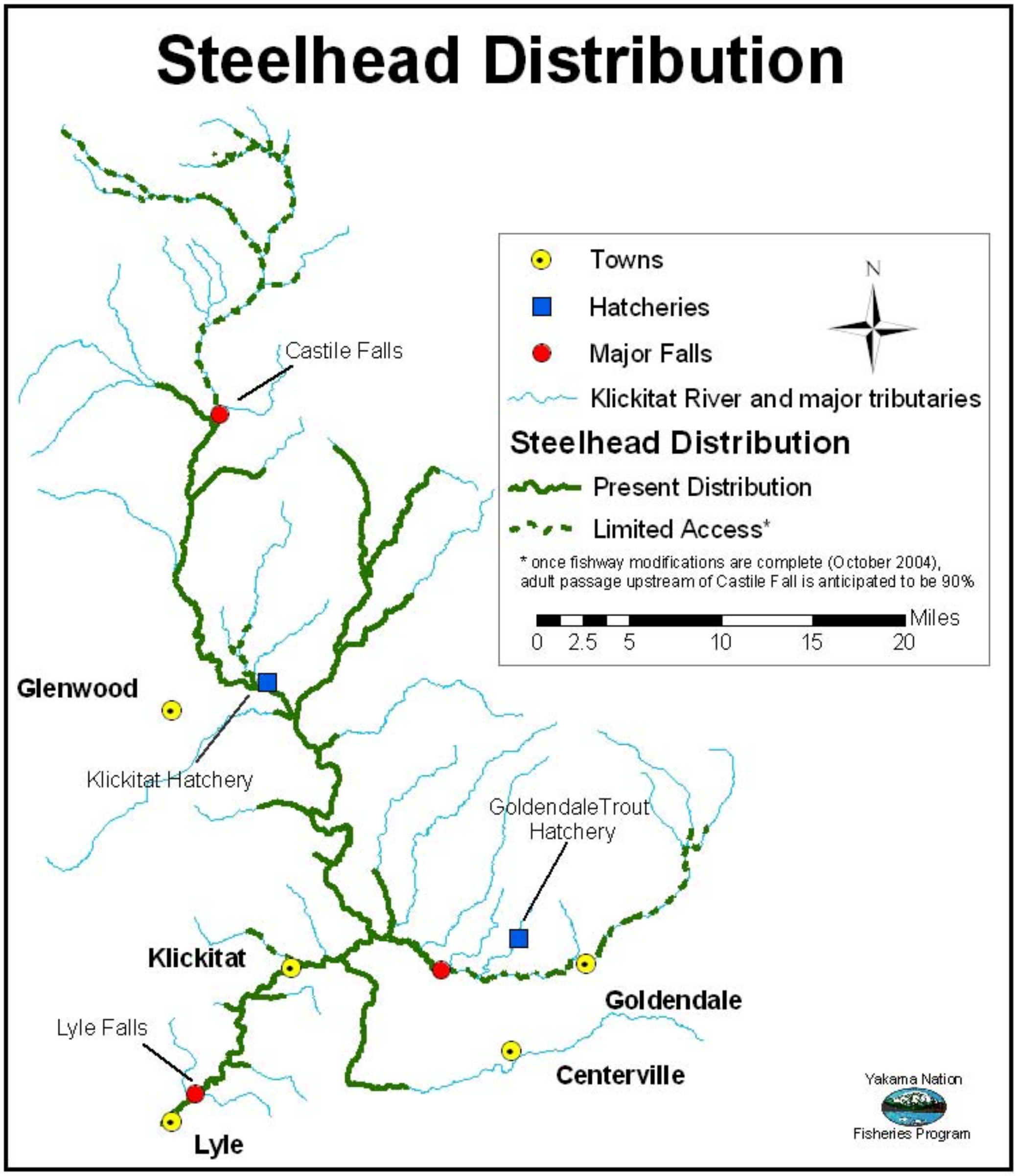
IHOT (Integrated Hatchery Operations Team). 1995. Operation plans for anadromous fish production facilities in the Columbia River basin. Volume III-Washington. Annual Report 1995. Bonneville Power Administration, Portland Or. Project Number 92-043. 536 pp.

NPPC 2004. Klickitat Subbasin Plan. Prepared for the Northwest Power and Conservation Council. Prepared by the Yakama Nation, Klickitat County, and Washington Department of Fish and Wildlife.

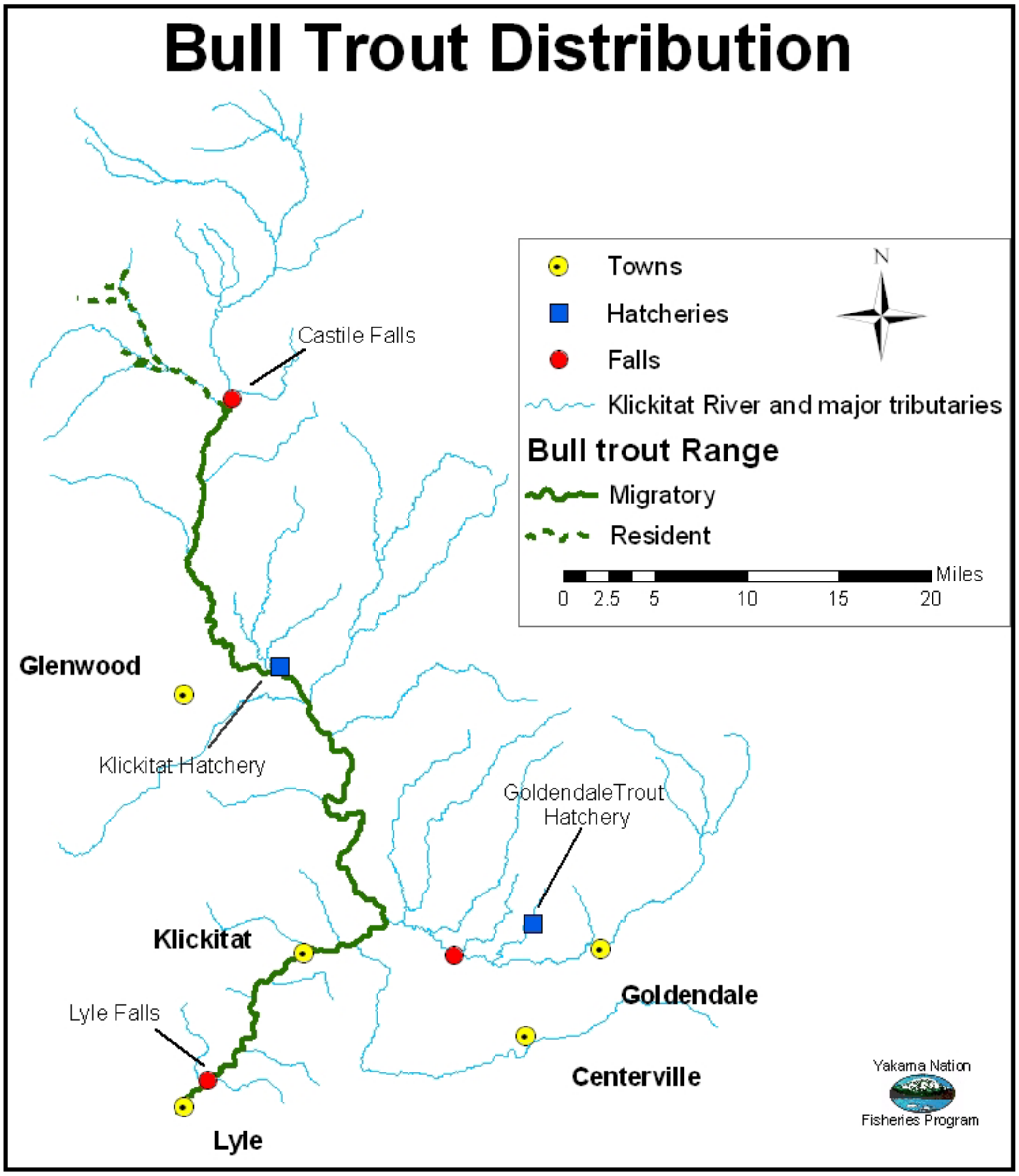
Yakama Nation 2008. *Draft* Klickitat Anadromous Fisheries Master Plan. Yakima/Klickitat Fisheries Program, Toppenish,WA.

Appendix A- Steelhead and Bull Trout Distribution

Steelhead Distribution



Bull Trout


Bull Trout Distribution
Towns
Hatcheries
Falls
Klickitat River and major tributaries
Bull trout Range
Migratory
Resident
N
Miles
0 2.5 5 10 15 20
Castile Falls
Glenwood
Klickitat Hatchery
GoldendaleTrout Hatchery
Klickitat
Goldendale
Centerville
Lyle Falls
Lyle
Yakama Nation
Fisheries Program

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Klickitat Spring Chinook Production Program Klickitat Hatchery

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HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Final Draft

Hatchery Program	Klickitat Spring Chinook Production Program-Klickitat Hatchery
Species or Hatchery Stock	Chinook Salmon *(Oncorhynchus tshawytscha)*
Agency/Operator	Yakama Nation
Watershed and Region	Klickitat River, Columbia Gorge
Date Submitted	February 2008
Date Last Updated	February 2008

Section 1: General Program Description

1.1 Name of hatchery or program.

Klickitat Spring Chinook Production Program- Klickitat Hatchery

1.2 Species and population (or stock) under propagation, and ESA status.

Klickitat Spring Chinook Salmon *(Onchorynchus tshawtscha)*

ESA Status: Not listed and not a candidate for listing

1.3 Responsible organization and individuals.

Name (and title):	**Jason Rau** (Klickitat Hatchery Complex Manager)
	Bill Sharp (YKFP Klickitat Coordinator)
Agency or Tribe:	Yakama Nation
Address:	PO Box 151 Toppenish WA 98948
Telephone:	(509) 865-5121
Fax:	(509) 865-6293
Email:	jayrau@ykfp.org sharp@yakama.com

Other agencies, Tribes, co-operators, or organizations involved,

including contractors, and extent of involvement in the program.

Co-operators	Role
WDFW	Hatchery Specialist 1
USFWS	Fish Health Services

1.4 Funding source, staffing level, and annual hatchery program operational costs.

Funding Sources
Mitchell Act

Operational Information	Contract Number NA06NMF4360230
Full time equivalent staff	6.0
Annual operating cost (dollars)	$435,000 (NPCC Step-1 estimate)

1.5 Location(s) of hatchery and associated facilities.

Broodstock source	Klickitat Hatchery/RKm 68/ Klickitat River
Broodstock collection location (stream, RKm, subbasin)	Lyle Falls Fishway/RKm 3.5/Klickitat River Klickitat Hatchery RKm 68
Adult holding location (stream, RKm, subbasin)	Klickitat Hatchery/RKm 68/ Klickitat River
Spawning location (stream, RKm, subbasin)	Klickitat Hatchery/RKm 68/ Klickitat River
Incubation location (facility name, stream, RKm, subbasin)	Klickitat Hatchery/RKm 68/ Klickitat River
Rearing location (facility name, stream, RKm, subbasin)	Klickitat Hatchery/RKm 68/ Klickitat River

1.6 Type of program.

Integrated Conservation/Harvest

The proposed integrated strategy for this program is based on assessment of the genetic characteristics of the hatchery and local natural population, as well as the current and anticipated productivity of the habitat used by the populations. Starting in brood year 2008, the Yakama Nation (YN) and Washington Dept. of Fish and Wildlife (WDFW) will be able to identify natural-origin (NOR) adult spring Chinook from hatchery origin (HOR) adult spring Chinook returning to the Subbasin. This will allow managers to convert the existing broodstock to NOR adults.

1.7 Purpose (Goal) of program.

- To provide harvest to tribal, sport fisheries, and commercial fisheries while preserving and protecting the indigenous spring Chinook population.
- To provide fish production to sustain tribal Zone 6 fisheries, sport and tribal fisheries at the mouth of the Klickitat River, in-river sport fisheries, and mixed stock ocean fisheries.
- Produce spring Chinook salmon to help mitigate for fish losses resulting from hydropower activities within the Columbia River Basin that have decreased salmonid populations

1.8 Justification for the program.

- The spring Chinook production program is funded through the Mitchell Act via NMFS for the purpose of mitigation for lost fish production due to development within the Columbia River Basin. The “Mitchell Act” (Act) (Public Law 75-502) was passed in 1938.
- Federal Court Decisions (US vs. Oregon and US vs. Washington) ruled that Indian Tribes who signed treaties with the federal government in the 1850s

have treaty rights to harvest a share (50%) of surplus fish resources.

- Yakima/Klickitat Fisheries Project (YKFP or Project)
- Pacific Northwest Electric Power Planning and Conservation Act.
- Columbia River Fisheries Development Program
- Columbia River Fish Management Plan

In order to minimize impact on listed fish by YN facilities operation and the Klickitat spring Chinook program, the following Risk Aversion measures are included in this HGMP:

Summary of risk aversion measures for the Klickitat Spring Chinook program

Potential Hazard	**Risk Aversion Measures**
Water Withdrawal	Water rights are formalized through trust water rights from the Department of Ecology. Monitoring and measurement of water usage is reported in monthly NPDES reports. Water withdrawals are not of an amount that has significant impact on the aquatic resources of the river.
Intake Screening	YN has requested funding for future scoping, design, and construction work of a new river intake system to meet NOAA compliance (Mitchell Act Intake and Screening Assessment 2002).
Effluent Discharge	Klickitat Hatchery operates under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) established by the US EPA and administered by the Washington Department of Ecology (DOE) - WAG 13-5002.
Broodstock Collection & Adult Passage	Broodstock will be collected at the new Lyle Falls Fishway, Castile Falls Fishway, and The Klickitat River Hatchery. All facilities will be designed to meet NMFS passage and fish handling criteria. The hatchery weir and associated intake facilities need repairs to provide compliant passage. These facility improvements will be implemented as funding allows.
Disease Transmission	*Fish Health Policy in the Columbia Basin*. Details hatchery practices and operations used to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).
Competition & Predation	Fish will be released volitionally from rearing ponds. Fish will be released at sizes similar to naturally produced spring Chinook juveniles.

1.9 List of program "Performance Standards".

See section 1.10

1.10 List of program "Performance Indicators", designated by "benefits" and "risks".

1.10.1 Benefits:

Benefits		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Assure that hatchery operations support Columbia River fish Mgt. Plan *(US v Oregon)*, production and harvest objectives.	Contribute to a meaningful harvest for sport, tribal and commercial fisheries (Harvest Goals in Master plan are 1,000 for combined mainstem fisheries (Zones 1-6: treaty (600), sport & commercial (400)) and 3,000 for combined terminal fisheries (1,800 treaty, 1,200 sport).	Survival and contribution to fisheries will be estimated for each brood year released. Work with co-managers to manage adult fish returning in excess of broodstock need.
Productivity	Observed average spawner recruit value of ~9.0) for hatchery spring Chinook	Productivity will be determined by counting tagged fish recovered at traps, broodstock collection facilities, sport and tribal fisheries and on the spawning grounds.
Straying of Klickitat River origin fish to other subbasins	Stray rate of less than 5%	Regional M&E efforts will be used to track the number and capture location of Klickitat River origin fish
Assure that the proportion of natural influence (PNI) achieves HSRG Targets	PNI Goal of 0.67	All spring Chinook released from the hatchery will be marked with either an elastomer or an adipose fin clip. This action will allow managers to determine broodstock composition, hatchery fish contribution to the natural spawning escapement, and natural fish contribution to hatchery broodstock.
Maintain outreach to enhance public understanding, participation and support of Yakama Nation YKFP salmon restoration programs.	Provide information about YN programs to internal and external audiences. For example, local schools and special interest groups tour the facility to better understand hatchery operations. Off station efforts may include festivals, classroom participation, stream adoptions and fairs.	Evaluate use and/or exposure of program materials and exhibits as they help support goals of the information and education program. Record on-station organized education and outreach events.
Program contributes to fulfilling tribal trust responsibility mandates and treaty rights	Follow pertinent laws, agreements, policies and executive and judicial orders on consultation and coordination with Native American tribal governments	Participate in annual coordination meetings between the co-managers to identify and report on issues of interest, coordinate management, and review programs.
Implement measures for broodstock management to maintain integrity and genetic diversity. Maintain effective population size. Maximize available Natural Origin Broodstock (NOB).	A minimum of 722 adults are collected throughout the spawning run in proportion to timing, age and sex composition of return. No more than 25% of the natural origin run will be used as hatchery broodstock.	Annual run timing, age and sex composition and return timing data are collected. Spawning surveys and fish counts at the new Lyle Falls fish facility will be used to ensure that natural escapement goals are met each year. Out-of-basin origin fish stocks will not be released into the Klickitat River.
Region-wide, groups are marked in a manner consistent with information needs and protocols to estimate impacts to natural and hatchery origin fish	200,000 NOR Elastomer Tags to track conversion to local broodstock. 30,000 with CWT 500,000 AD-clip HOR 102,000 with CWT.	Returning fish are sampled throughout their return for length, sex, and marks. Scale samples will be collected to determine HOR and NOR adults used for hatchery broodstock; this data will be used to determine if unmarked fish are the results of poor tagging techniques or lost tags.

Benefits		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Maximize survival at all life stages using disease control and disease prevention techniques. Prevent introduction, spread or amplification of fish pathogens. Follow Co-managers Fish Health Disease Policy (WDFW and NWIFC 1998).	Necropsies of fish to assess health, nutritional status, and culture conditions	USFWS Fish Lower River Fish Health Center pathologist inspects adult broodstock yearly and monitor juvenile fish on a monthly basis to assess health and detect potential disease problems. As necessary, the USFWS pathologist recommends remedial or preventative measures to prevent or treat disease, with administration of therapeutic and prophylactic treatments as deemed necessary A fish health database will be maintained to identify trends in fish health and disease and implement fish health management plans based on findings.
	Release and/or transfer exams for pathogens.	1 to 6 weeks prior to transfer or release, fish are examined in accordance with the Co-managers Fish Health Policy.
	Inspection of adult broodstock for parasites and pathogens.	At spawning, lots of 60 adult broodstock are examined for pathogens.
	Inspection of off-station fish/eggs prior to transfer to hatchery for pathogens.	Controls of specific fish pathogens through eggs/fish movements are conducted in accordance to Co-managers Fish Health Disease Policy (WDFW and NWIFC 1998).

1.10.2 Risks:

Risks		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Minimize impacts and/or interactions to ESA listed fish.	Hatchery operations will comply with all state and federal regulations (See below). Smolts will be released at a size (12-15 fpp) and condition that ensures they migrate rapidly from the system after release.	Monitor and report size, number, date of release and mass mark quality. ATPase data will be collected on juveniles prior to release to document smoltification levels. NOR/HOR ratio on the spawning grounds and broodstock will be monitored.
Disease: Artificial production facilities are operated in compliance with all applicable fish health guidelines, facility operation standards and protocols including IHOT, Co-managers Fish Health Policy and drug usage mandates from the Federal Food and Drug Administration	Hatchery goal is to prevent the introduction, amplification or spread of fish pathogens that might negatively affect the health of both hatchery and naturally reproducing stocks and to produce healthy smolts that will contribute to the goals of this facility.	Pathologists from USFWS Lower River Fish Health Center monitor program monthly. Exams performed at each life stage may include tests for virus, bacteria, parasites and/or pathological changes, as needed.
Water Quality: Ensure hatchery operations comply with state and federal water quality and quantity standards through proper environmental monitoring	NPDES permit compliance YN water right-permit compliance.	Flow and discharge reported in monthly NPDES reports.
Entrainment/ Blockage: Water withdrawals and instream water diversion structures for hatchery facility will not affect spawning behavior of natural populations or impact juveniles.	Hatchery intake structures meet state and federal guidelines where located in fish bearing streams.	Barrier and intake structure compliance assessed and needed fixes are prioritized.

Risks		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Hatchery operations comply with ESA responsibilities.	YN completes an HGMP and is issued a federal and state permit when applicable.	Identified in HGMP and Biological Opinion for hatchery operations.
Harvest of hatchery-produced fish minimizes impact to wild populations.	Harvest is regulated to meet appropriate biological assessment criteria. Mass mark juvenile hatchery fish prior to release to enable state agencies to implement selective fisheries.	Harvests are monitored by agencies and tribes to provide up to date information..

1.11.1 Proposed annual broodstock collection level (maximum number of adult fish).

722 adults at 1:1 female to male ratio.

1.11.2 Proposed annual fish release levels (maximum number) by life stage and location.

Age Class	Max. No.	Size (fpp)	Release Date	Location			
				Stream	Release Point (RKm)	Major Water-shed	Eco-province
Yearling (NOR Broodstock)	200,000	12 -15	April	Klickitat	RKm 102	Upper Klickitat	Columbia Gorge
Yearling (HOR)	600,000	12 -15	March	Klickitat	RKm 68	Klickitat	Columbia Gorge

1.12 Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.

Brood Year	Smolt to Adult Survival (%)
1990	0.08
1991	0.19
1992	0.29
1993	0.09
1994	0.01
1995	0.14
1996	0.54
1997	0.10
1998	0.62
1999	1.31
2000	0.32

*YKFP Hatchery database 2008

Return Year	Total Run	Hatchery Escapement
1990	2,325	817
1991	1,250	646
1992	1,163	737
1993	3,020	1,797
1994	899	687
1995	842	705
1996	859	608
1997	1,114	835
1998	481	375
1999	1,021	813
2000	1,835	768
2001	1,023	661
2002	1,650	1,296
2003	2,280	1,352
2004	2,863	1,524
2005	1,120	582

1.13 Date program started (years in operation), or is expected to start.

The first year of operation for this hatchery was 1951.

1.14 Expected duration of program.

The program is on-going with no planned termination. If adult escapement goals for stream reaches above Castile Falls are achieved, hatchery releases would be eliminated in this portion of the Subbasin and hatchery production (200,000) would be shifted to lower Klickitat River.

1.15 Watersheds targeted by program.

Klickitat Subbasin/Columbia Gorge Province

1.16 Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

1.16.1 Potential Alternatives to the Current Program:

Alternative 1 – Status Quo: Maintain current segregated hatchery program. This program did not protect the natural spring Chinook stock in the Subbasin and also did not meet tribal and sport harvest objectives and was therefore rejected

Alternative 2- Using 100% NOR as broodstock. Habitat quantity and quality in the Klickitat River was insufficient to meet natural production escapement goals (500) and provide broodstock (722) needed for the hatchery program.

A more detailed description of these alternatives can be found in the Klickitat River Anadromous Fisheries Master Plan (Yakama Nation 2008, in draft).

1.16.3 Potential Reforms and Investments:

Reform/Investment 1: Construct Lyle Falls trap in lower river to increase monitoring capabilities, and broodstock collection efficiency.

Section 2: Program Effects on ESA-Listed Salmonid Populations

2.1 List all ESA permits or authorizations in hand for the hatchery program.

Program is described in the Biological Assessment For The Operation Of Hatcheries Funded by The National Marine Fisheries Service (March 1999), Statewide Section 6 consultation with USFWS for interactions with Bull Trout, and concurrent with this HGMP to satisfy Section 7 consultations: the YN is writing HGMPs to cover all hatchery programs in the Klickitat River.

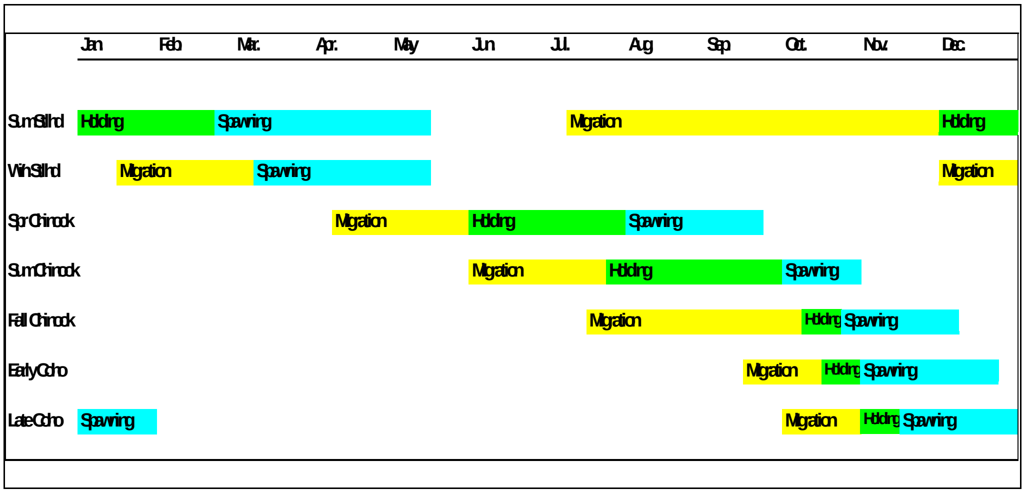
2.2 Descriptions, status and projected take actions and levels for ESA-listed natural populations in the target area.

ESA listed stock	Status	Take Level	Action
Summer Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls
Winter Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls
Bull Trout – Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls

Spring Chinook adults used as broodstock will be collected at Lyle Falls. Trapping could result in the capture and/or injury of native steelhead and bull trout.

2.2.1) Description of ESA-listed salmonid population(s) affected by the program.

Adult and juvenile run-timing for listed steelhead and other fish species are presented in the figure below.



The majority of the steelhead population is found from the mouth of the Klickitat River to Castile Falls. Steelhead access to areas above Castile falls has been limited due to poor natural migration conditions at the falls. Steelhead spawning is concentrated between RKm 8 and 80. Tributary spawning occurs in Swale, Swift, Summit and White Creeks, the lower Little Klickitat River and other small tributaries.

Klickitat River bull trout life history characteristics are not well understood at this time. Research is on-going to collect more data on this species. Bull trout are found in the West Fork and many of its tributaries. Electro-fishing work has shown that bull trout in the West Fork are likely resident, based on the size of fish collected (~ 10 inches). Falls on the West Fork likely isolate most of the resident bull trout population from the mainstem Klickitat River.

Based on limited data, it is thought that an adfluvial population of bull trout may be present in the lower Klickitat River below Lyle Falls. Additional work is on-going to determine bull trout abundance and distribution in the lower river.

Maps depicting steelhead and bull trout distribution in the Klickitat River are presented in Appendix A.

Identify the ESA-listed population(s) that will be directly affected by the program

No NMFS ESA-listed populations will be directly affected by this program.

Identify the ESA-listed population(s) that may be incidentally affected by the program

Middle Columbia River Steelhead March 19, 1998; 64 FR 14508. Threatened
Columbia Basin DPS Bull Trout June 10, 1998 (63 FR 31647), Threatened.

2.2.2 Status of ESA-listed salmonid population(s) affected by the program.

Middle Columbia River Steelhead *(Oncorhynchus mykiss*) March 19, 1998; 64 FR 14508, Threatened. Within the Middle Columbia River Steelhead ESU, hatchery STHD stocks from outside the ESU are imported and released into the White Salmon (Skamania Hatchery winter and summer steelhead), Klickitat (Skamania Hatchery winter and summer steelhead) and Walla Walla (Lyons ferry), The BRT concluded that the Middle Columbia steelhead ESU is not presently in danger of extinction, but reached no conclusion regarding its likelihood of becoming endangered in the foreseeable future. Winter steelhead are reported within this ESU only in the Klickitat River and Fifteenmile Creek. Information on steelhead abundance, productivity and population growth trends is reported in NOAA 2005.

Summer and Winter Runs:
The existence of naturally spawning winter steelhead was confirmed in the early 1980s, and winter steelhead are presumed to be indigenous. Howell et al. (1985) recognized both summer and winter races of steelhead in the Klickitat Subbasin, with an adult winter steelhead migration period of January through May and a spawning period of March through June. To protect the winter run, current regulations prohibit sport fishing for steelhead in the Klickitat River from December through May and the treaty fishery is closed from January through March. Both seasons have been longer in previous years.

The years 1996-2006 (See steelhead HGMP) comprise the most comprehensive set of steelhead spawner survey data. Redd counts over these years indicate an average escapement of 260 fish. This figure is undoubtedly an underestimate due to the inherent difficulty in conducting accurate counts during spring flow conditions. Mainstem spawning distribution is concentrated between RKm 8 and RKm 80.0, with occasional spawning above Castile Falls. Tributary spawning occurs in Swale, Wheeler, Summit, and White creeks and the upper Little Klickitat River.

Columbia Basin DPS Bull Trout *(Salvelinus confluentu*s) June 10, 1998 (63 FR 31647), Threatened.
The Fish and Wildlife Service issued a final rule listing the Columbia River and Klamath River populations of bull trout *(Salvelinus confluentu*s) as a threatened species under the Endangered Species Act on June 10, 1998 (63 FR 31647). The Columbia River Distinct Population Segment is threatened by habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, and past fisheries management practices such as the introduction of non-native species.

The Lower Columbia Recovery Unit Team identified two core areas (Lewis and Klickitat rivers) within the recovery unit. The Klickitat Core Area includes all tributaries downstream to the confluence with the Columbia River. Recent evidence indicates both resident and adfluvial bull trout are present in the Subbasin. Numerous confirmed and anecdotal reports of bull trout exist in the mainstem Klickitat River from the mouth up to the area below Castile Falls. Sizes reported are indicative of an adfluvial life history. Presence of resident populations has also been documented in the West Fork Klickitat River, Fish Lake Stream, Little Muddy Creek, Trappers Creek, Clearwater Creek, Two Lakes Stream, and an unnamed tributary to Fish Lake Stream (all within the West Fork Klickitat watershed).

The abundance of the stock in the Klickitat River is poorly known. There are insufficient data to make an assessment. However, it appears that there are very few bull trout in the lower- to mid-Klickitat drainage. Bull trout appear to be more abundant in the upper drainage where habitat conditions are more favorable.

Preliminary results of recent genetic analysis indicate that resident bull trout in the Klickitat Subbasin are genetically distinct from other Columbia tributary populations, but that fish in two West Fork Klickitat tributaries (Trappers and Clearwater creeks) do not differ significantly from each other.

The impacts of hatchery salmon and steelhead in the main Klickitat River on bull trout are not known. Generally, in drainages colonized by anadromous salmon and steelhead, char successfully co-exist by occupying a different ecological niche. However, negative interactions (predation) may occur when hatchery fish are released near char spawning and rearing areas.

2.2.3 Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed fish in the target area, and provide estimated annual levels of take.

Describe hatchery activities: The following activities listed below are identified as general hatchery actions that are identified in the ESA Section 7 Consultation “Biological Opinion on Artificial Propagation in the Columbia River Basin” (March 29, 1999) (NMFS 1999).

Broodstock Program

Broodstock Collection: Broodstock will be collected for this program mainly at Lyle Falls from (April -July, Castile Falls (May-August) and, in some years, at the Klickitat Hatchery (April-August). No listed fish mortalities have been observed during broodstock collection activities at the Klickitat Hatchery (R. Ballard, WDFW pers. comm. 2004). The operation of the new adult collection facilities at Lyle Falls and Castile Falls will likely result in some (~50) ESA-listed steelhead being handled as the facilities will be operated during times of the year when steelhead may be migrating to spawning grounds. However, as noted, the data collected on adults at the Klickitat River Hatchery has shown that mortality is unlikely. Additionally, the facilities will be designed to meet NMFS passage and handling criteria which should minimize stress and associated mortality rates on handled fish.

Rearing Program

Operation of Hatchery Facilities: Indirect take for listed species is unknown from operation of the hatchery facility. Activities that may impact listed fish species include:

Water diversion: Water is diverted from the stream for hatchery operations. This results in a decrease in the amount and quality of approximately 0.25 of stream habitat. The loss in habitat may result in a decrease in steelhead and bull trout abundance; although this has not been quantified, it is expected to be negligible. In addition, The Mitchell Act Intake and Screening Assessment (2002) has identified design and alternatives needed to get existing structures in compliance with NOAA fish screening standards. From the assessment, YN has been requesting funding for future scoping, design, and construction work of a new intake system.

Water Quality: This facility operates under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). Monthly and annual reports on water quality sampling, use of chemicals at this facility, compliance records are available from DOE. Discharges from the cleaning treatment system are monitored as follows:

Total Suspended Solids (TSS): Collected 1 to 2 times per month on composite effluent, maximum effluent and influent samples.

Settleable Solids (SS) Collected 1 to 2 times per week on effluent and influent samples.

In-hatchery Water Temperature - Daily maximum and minimum readings.

Water quality monitoring is not expected to result in the take of listed species.

Disease: Outbreaks in the hatchery may cause significant adult, egg, or juvenile mortality. Over the years, rearing densities, disease prevention and fish health monitoring have greatly improved the health of the programs at Klickitat Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the population health.

<u>Indirect take from disease is unknown.</u>

Release Program

Competition and Predation: According to the HSRG (2004) and Flagg et al. (2000), the potential for predation of wild salmonids by hatchery-reared smolts will depend on the size, number, and spatial distribution of both predators and prey, the functional and numerical responses of the predators, and the amount of time that predators and prey are in proximity. Busack et al. (2005) reviewed published rates of predation by juvenile hatchery salmonids on wild juvenile Chinook and found predation rates were generally low (<2% of natural population consumed). In contrast, data collected on hatchery coho predation rates on wild fall Chinook juveniles in the Lewis River were quite high (>11%) (Hawkins and Tipping 1999). The variability in study results is one reason the HSRG (2004) suggests that hatcheries monitor predation impacts resulting from hatchery releases.

In general, hatchery fish can consume fish that are 50% of their body size, however studies reviewed by Busack et al. (2005) indicated that the range may extend from approximately 38% (steelhead) to 75% (coho). NOAA Fisheries and the USFWS in a number of biological assessments and opinions (e.g. USFWS 1994; NMFS 1999) were of the opinion that juvenile salmonids can consume prey at ~33% of their body length. Predation by hatchery fish on wild fish can occur anywhere the two stocks exist in space and time. Therefore, predation may not only be a concern in the stream environment, but also in the estuary and marine environment.

The site-specific nature of predation and the limited number of empirical studies that have been conducted, make it difficult to predict the predation effects of this specific hatchery release. The YN is unaware of any studies that have empirically estimated the predation risks to listed fish posed by the Klickitat Hatchery programs. In the absence of site-specific empirical information, the identification of risk factors can be a useful tool for reviewing hatchery programs while monitoring and research programs are developed and implemented.

Risk Factors:

Date of Release: The release date can influence the likelihood that listed species are encountered. Spring Chinook will be released in March and April, which is before listed steelhead fry emerge from the gravel. Therefore, spring Chinook predation on listed steelhead fry is unlikely.

Fish Size at Release: Based on the 33% of body length predation assumption put forward by NMFS and USFWS, and a spring Chinook size of release range of 139-155 mm, hatchery Chinook may consume listed steelhead that range in size from 46-51 mm. During the time of release (March-April) the majority of steelhead juveniles present in the system are expected to be 1+ smolts that are generally larger than 80 mm. These fish are too large to be consumed by spring Chinook hatchery fish. However this assumption regarding predation and size has not been confirmed.

Release Location and Release Type: The likelihood of predation may also be affected by the location and the type of release. Other factors being equal, the risk of predation may increase with the length of time that fish co-mingle. In the freshwater environment, this is likely to be affected by distribution of the listed species in the watershed, the location of the release and the speed at which fish released from the program migrate. Spring Chinook will be released volitionally from rearing sites located at RKm 68. Based on data collected in the Cowlitz River (Harza 1998), salmon smolts are likely to migrate more than 25 kilometers per day. At this migration rate, spring Chinook should take from 1 to 7 days to migrate out of the basin. The small amount of time the hatchery fish are present in the Klickitat River should reduce possible competition and predation effects to listed fish species.

Residualism: To maximize smolting characteristics and minimize residualism, the YN adheres to a combination of acclimation, volitional release strategies, size, and time guidelines as developed at the Cle Elum Supplementation and Research Facility (CESRF) for spring Chinook. For the spring Chinook yearling program the following actions are taken to reduce residualism:

Feeding rates and regimes throughout the rearing cycle are to be programmed to satiation feeding to minimize size variations and reprogrammed as needed to achieve goals for smolt size at time of release.

Fish Condition factors, standard deviation and co-efficient of variation (CV) on lengths of fish will be collected throughout the rearing cycle. The data are used to confirm that fish growth rates achieve size at release targets.

Releases from the hatchery and acclimation sites are set to mimic wild fish emigration timing.

Releases from acclimation ponds will be volitional so that fish not ready to migrate are not released from the ponds. This action should reduce competition effects to wild populations. ATPase data will be collected to confirm the onset and pace of smoltification.

Migration Corridor/Ocean*:* The Columbia River hatchery production ceiling, called for in the Proposed Recovery Plan for Snake River Salmon of approximately 197.4 million fish (1994 release levels), has been incorporated by NOAA-Fisheries into their recent hatchery biological opinions to address potential mainstem corridor and ocean effects, as well as other potential ecological effects from hatchery fish. Although hatchery releases occur throughout the year, approximately 80% occur from April to June and Columbia River mainstem out-migration occurs primarily from April through August (www.fpc.org). It is unknown to what extent listed fish are available both behaviorally and spatially on the migration corridor. Witty et al. (1995)

concluded that, once in the main stem Columbia River, predation by hatchery production on wild salmonids does not significantly impact naturally produced fish survival in the Columbia River migration corridor. In a study designed to define the migrational characteristics of Chinook salmon, coho salmon, and steelhead trout in the Columbia River estuary, Dawley et al (1984) found the average migration rates for subyearling Chinook, yearling Chinook, coho, and steelhead, were 22, 18, 17, and 35 RKm/d respectively. There appear to be no studies demonstrating that large numbers of Columbia system smolts migrating to the ocean affect the survival rates of juveniles in the ocean. The lack of studies is due in part to the dynamics of fish rearing conditions in the ocean and an inability to measure ocean survival rates.

Monitoring:

- Smolt Monitoring- Smolt traps above Castile Falls, near the Klickitat Hatchery and lower Klickitat River will be used to monitor hatchery fish migration timing and abundance.

- Adult trapping at Lyle Falls, Castile Falls and Klickitat River Hatchery will be monitored for impacts to listed adults.

These activities have the potential to harass, kill or injured handled fish as evidenced by the data presented in the following table:

The number of juvenile steelhead handled and resultant mortality at the Lyle Falls rotary screw trap (2003-2006).

	Workups		Tallies		Grand Totals		
Year	Morts	Total Handled	Morts	Total Handled	Morts	Total Handled	% mortality
2003	8	764	64	515	72	1279	5.6%
2004	1	486	110	2054	111	2540	4.4%
2005	1	379	8	817	9	1196	0.8%
2006	0	81	0	35	0	116	0%
Totals					192	5131	3.7%

Research:

No research program is associated with the spring Chinook hatchery program.

Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

Data on the take of listed species is presented in the following table. It is anticipated that up to 50 steelhead adults may be handled at upstream trapping facilities. It must be noted that natural-origin steelhead will also be collected for the Klickitat River Hatchery Steelhead Program. As long as both hatchery programs are operational, impacts to adult steelhead will be shared.

If the steelhead program is discontinued, the 50 adult take would apply only to the spring Chinook program.

Estimated listed salmonid take levels by hatchery activity.
Steelhead

ESU/Population	Middle Columbia River Steelhead
Activity	Klickitat Hatchery Spring Chinook Program
Location of hatchery activity	Klickitat R. Hatchery
Dates of activity	May – September
Hatchery Program Operator	WDFW

	Annual Take of Listed Fish by life Stage (number of fish)			
Type of Take	Egg/Fry	Juvenile /Smolt	Adult	Carcass
Observe or harass (a)				
Collect for transport (b)				
Capture, handle, and release (c)		*5,000	50*	
Capture, handle, tag/mark/tissue sample, and release (d)				
Removal (e.g., broodstock) (e)				
Intentional lethal take (f)				
Unintentional lethal take (g)				
Other take (indirect, unintentional) (h)				

* Past juvenile trapping operations for monitoring purposes not associated with the program have captured ~5,000 steelhead parr and smolts.
** Although steelhead have not been taken during past hatchery practices, it is anticipated that adult steelhead will be collected and handled at the new collection facilities at Lyle Falls and Castile Falls. No mortality is expected from these operations.

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.

e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

Any mortality or handling of listed steelhead that exceeds the values shown above will be communicated to Fish Program staff for additional guidance. The YN Senior Fisheries Biologist, along with the Hatchery Complex Manager, will determine an appropriate plan of action through consultation with NOAA-Fisheries. With the exception of unusual events that could not be foreseen, take limits will not be exceeded without prior approval from NOAA-Fisheries.

Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish.

Fisheries managers report that listed steelhead have not been taken as part of this program.

Section 3: Relationship of Program to Other Management Objectives

3.1 Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. *Hood Canal Summer Chum Conservation Initiative*) or other regionally accepted policies (e.g. the *NPPC Annual Production Review* Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.

For ESU-wide hatchery plans, the release of hatchery spring Chinook into the Klickitat River is consistent with:

- 1999 Biological Opinion on Artificial Propagation in the Columbia River Basin (NMFS 1999)
- Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995)
- The *U.S. v. Oregon* Columbia River Fish Management Plan
- Columbia River Basin Fish and Wildlife Program (http://www.nwcouncil.org/library/2000/2000-19/Default.htm)
- Principles and Recommendations of the HSRG (HSRG 2004)
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- Klickitat River Master Plan (2007)
- Draft Klickitat Subbasin Recovery Plan for Middle Columbia River Steelhead ESU. (NOAA-Portland 2007)

For statewide hatchery plan and policies, hatchery programs in the Columbia system adhere to a number of guidelines, policies and permit requirements in order to operate. These constraints are designed to limit adverse effects on cultured fish, wild fish and the environment that might result from hatchery practices. Following is a list of guidelines, policies and permit requirements that govern Columbia hatchery operations for the production of spring Chinook for the Klickitat River:

Genetic Manual and Guidelines for Pacific Salmon Hatcheries in Washington. These guidelines define practices that promote maintenance of genetic variability in propagated salmon.. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).

Hatchery Reform: Principles and Recommendations of the Hatchery Scientific Review Group (HSRG): Provides guidance on hatchery operations and their impacts to native salmon populations. The program is using HSRG recommendations for broodstock management.

Stock Transfer Guidelines: This document provides guidance in determining allowable stocks for release for each hatchery. It is designed to foster development of locally adapted broodstock and to minimize changes in stock characteristics brought on by transfer of non-local salmonids (WDF 1991).

Spawning Guidelines: provides guidance on the mating and spawning protocols followed at WDFW hatcheries (Seidel 1983).

Fish Health Policy in the Columbia Basin: Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Fish Policy Chapter 5, IHOT 1995).

National Pollutant Discharge Elimination System Permit Requirements This permit sets forth allowable discharge criteria for hatchery effluent and defines acceptable practices for hatchery operations to ensure that the quality of receiving waters and ecosystems associated with those waters are not impaired.

3.2 List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

The program described in this HGMP is consistent with the following agreements and plans:

- The Columbia River Fish Management Plan
- Klickitat River Master Plan
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- U.S. vs. Oregon court decision
- Production Advisory Committee (PAC)
- Technical Advisory Committee (TAC)
- Integrated Hatchery Operations Team (IHOT) Operation Plan 1995 Volume III.
- Pacific Northwest Fish Health Protection Committee (PNFHPC)
- In-River Agreements: State, Federal, and Tribal representatives
- Northwest Power Planning Council Sub Basin Plans
- Washington Department of Fish and Wildlife Wild Salmonid Policy
- Memorandum of Understanding WDFW and YN for Operation of the Klickitat River Hatchery

3.3 Relationship to harvest objectives.

The hatchery program has been designed to help meet tribal treaty trust obligations as defined by Federal Courts.

A Federal court decision in 1969 (*U.S. vs. Oregon*) ruled that Columbia River Treaty Tribes who signed treaties with the federal government in the 1850s are entitled to half of all harvestable salmon and steelhead destined for the tribes' traditional fishing grounds. This court decision mandated fisheries management cooperatively in a government-to-government relationship between the states of Oregon and Washington and the treaty Indian tribes.

U.S. v. Oregon/Columbia River Compact fisheries Technical Advisory Committee impact assessments are evaluated through Section 7/10 consultation process. Commercial fishery seasons on the portion of the mainstem Columbia River where the states of Oregon and Washington share a common boundary are regulated by a joint Oregon and Washington regulatory body (the Columbia River Compact). Meetings are held in late January of each year to establish the harvest guidelines for the spring and summer fisheries and in late July to establish guidelines for fall commercial and sport fisheries.

In addition, the program is coordinated with and incorporated into WDFW's Mid Columbia River Region (MCMA) Fish Management and Evaluation Plan (FMEP March 2003 and NOAA 2007).

Because no listed Chinook stocks are present in the Klickitat River, harvest activity impacts on listed Chinook stocks are not applicable. The biological impacts of the program to listed steelhead and bull trout have been reduced by releasing fish at sizes typical of wild, fish, and implementing volitional release strategies that help ensure that fish migrate quickly out of the system. Both actions reduce competition and predation interactions between hatchery and listed fish stocks.

3.3.1 Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years (1994-2005), if available.

Recent 12-year averages (1994-2005) for the combined terminal fishery averaged 498 spring Chinook. Sport and treaty Indian fisheries have averaged 230 and 267 respectively.

Klickitat River Terminal harvest over last 12 years (1994-2005)

Return Year	Sport Harvest	Tribal Harvest	Total Catch (all ages)
1994	44	167	212
1995	11	125	137
1996	123	128	251
1997	162	116	279
1998	12	94	106
1999	105	103	208
2000	366	700	1,067
2001	136	226	362
2002	104	250	354
2003	425	503	928
2004	985	355	1,339
2005	189	349	538
2006	333	360	693

3.4 Relationship to habitat protection and recovery strategies.

The program described in this HGMP is consistent with the following habitat and protection strategies:

Klickitat Subbasin Recovery Plan for the Mid Columbia ESU- This plan provides habitat strategies to be used to recover ESA listed steelhead in the Klickitat Subbasin. The hatchery program has considered current and future habitat conditions in sizing program and defining release locations.

Klickitat River Master Plan (2007): This document describes actions needed to protect and restore stream habitat in the Klickitat River as well as the basis for hatchery operations.

Yakama Nation Fisheries Program (YNFP):
The Lower Klickitat Riparian and In-Channel Habitat Enhancement Project is a BPA-funded watershed restoration project implemented by the Yakama Nation Fisheries Program (YNFP). The YNFP is working in coordination with WDFW, Natural Resources Conservation Service (NRCS), and the Central Klickitat Conservation District. The project was proposed under the Northwest Power Planning Council's Fish and Wildlife Program and funded by BPA in 1997. Initial project restoration projects were located within the Swale Creek and Little Klickitat River watersheds. Included in the project scope of work are in-stream structural modifications, re-vegetation of the riparian corridor, construction of sediment retention ponds to provide late-season flow to the creek and exclusion fencing to prevent channel degradation from livestock. A monitoring program has been initiated to document project success and guide future restoration activities. The second phase of the project will use EDT modeling output to guide and prioritization restoration activities.

Subbasin Planning:
A regional Subbasin planning process is a broad-scale initiative that will provide building blocks of recovery plans for listed fish. The spring Chinook hatchery program is designed to be consistent with the goals identified in this plan (NPPC 2004).

Limiting Factors Analysis:
A WRIA 30 (Klickitat Basin) habitat limiting factors report (LFA) has been completed by the Washington State Conservation Commission. This limiting habitat factors analysis was conducted pursuant to RCW 75.46 (Salmon Recovery). The purpose of this analysis was "to identify the limiting factors for salmonids" where limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon." It was intended that a locally based habitat project selection committee use the findings of this analysis to prioritize appropriate projects for funding under the state salmon recovery program. The hatchery program used information from this study and others to size hatchery releases upstream of Castile Falls. As habitat improves from the implementation of habitat projects, hatchery releases will be reduced or eliminated in this area to protect natural spawning spring Chinook (Washington State Conservation Commission 1999).

3.5 Ecological interactions.

Below are discussions on both negative and positive impacts relative to the Klickitat spring Chinook program.

(1) Salmonid and non-salmonid fishes or species that could negatively impact the program: Klickitat spring Chinook smolts can be preyed upon through the entire migration corridor from the Subbasin to the mainstem Columbia River and estuary. Northern pikeminnows and introduced spiny rays along the Columbia mainstem sloughs can prey on smolts reducing their abundance. In addition, avian predators, including gulls, mergansers, cormorants, belted kingfishers, great blue herons and night herons are also known to take large numbers of smolts as they migrate to the ocean. Mammals that can take a heavy toll on migrating smolts and returning adults include harbor seals, sea lions, river otters, and Orcas.

(2) Salmonid and non-salmonid fishes or species that could be negatively impacted by the program: Natural salmon and steelhead populations that co-exist in local tributary areas and the Columbia River mainstem corridor areas could be negatively impacted by program fish. Of primary concern are the ESA -listed endangered and threatened salmonids: Snake River fall-run Chinook salmon ESU (threatened); Snake River spring/summer-run Chinook salmon ESU (threatened); Lower Columbia River Chinook salmon ESU (threatened); Upper Columbia River spring-run Chinook salmon ESU (endangered); Columbia River chum salmon ESU (threatened); Snake River sockeye salmon ESU (endangered); Upper Columbia River steelhead ESU (endangered); Snake River Basin steelhead ESU (threatened); Lower Columbia River steelhead ESU (threatened); Middle Columbia River steelhead ESU (threatened); and the Columbia River distinct population segment of bull trout (threatened). Listed fish can be impacted through a complex web of short- and long-term processes and over multiple time periods which makes evaluation of this net effect difficult.

3) Salmonid and non-salmonid fishes or other species that could positively impact the program.

Other wild and hatchery salmonids may provide nutrients to the Klickitat River upon their return as adults. These carcasses may increase stream productivity, which in turn may increase food abundance for spring Chinook. Benefits are expected to be minor as smolts are not expected to remain within the Subbasin for more than ~1-week after release.

4) Salmonid and non-salmonid fishes or species that could be positively impacted by the program.

Aquatic and terrestrial species that consume salmonids will benefit from the continued release of fish from this program. Common species that may benefit include northern pikeminnow, smallmouth and largemouth bass, gulls, mergansers, cormorants, belted kingfishers, great blue herons and night herons, harbor seals, sea lions, river otters, bear and killer whales (Orcas). Additionally, salmon carcasses act as a source of fertilizer that benefit riparian plants and return nutrients to the stream.

Section 4. Water Source

4.1 Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile and natural limitations to production attributable to the water source.

Spring water from Indian Ford A Springs and gravity-intake-fed river water supply most of the water for this program, although there are several non-fish bearing streams near the grounds that could be used. Indian Ford Springs provide up to 7,000 gpm of good quality water at 48 –52 degreesF. The river intake supplies up to 7,000 gpm of river water. River pumps (that have not been used since 2001) can provide up to 4,000 gpm surface water. Spring water is used for the incubation and early rearing of all juveniles. In late summer, river water is introduced for coho acclimation to Pond 25, located across the river from the hatchery. Fish can be reared in Pond 26, which is supplied with spring water from Wonder Springs, approximately one-half mile downstream and across the river from the main hatchery. Ponds 24 also is used for fish acclimation and is supplied by both spring and re-use water from hatchery raceway banks.

Pond 25 intake screens do not currently meet NMFS screening criteria which may pose problems for juvenile steelhead and other species. Funding is being sought to replace the screens.

A new acclimation facility may be proposed at McCreedy Creek above Lyle Falls. This facility would be constructed only if spring Chinook are unable to colonize newly opened habitat above Castile Falls. The site will use creek water that is dominated by springs for juvenile rearing. The water source has no known problems in regards to successfully rearing spring Chinook juveniles for 6 weeks.

4.2 Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

Potential Hazard	Risk Aversion Measure
Hatchery water withdrawal	Water rights total 6000 – 8000 gpm from the gravity intake with another 4,000 pumped from the river. Water rights are formalized through trust water right from the Department of Ecology. Monitoring and measurement of water usage is reported in monthly NPDES reports.
Intake/Screening Compliance	Intake structures were designed and constructed to specifications at the time the Klickitat facility was constructed. The Mitchell Act Intake and Screening Assessment (2002) has identified design and alternatives needed to get existing structures in compliant including intake screens and velocity sweeps which are not in compliant with NOAA fish screening standards. As a result of the recent assessment, YN has requested funding for future scoping, design, and construction work of a new intake system.

Hatchery effluent discharges. (Clean Water Act)	This facility operates under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). WAG 13-5002. Monthly and annual reports on water quality sampling, use of chemicals at this facility, compliance records are available from DOE. Discharges from the cleaning treatment system are monitored as follows: *Total Suspended Solids (TSS):* Collected 1 to 2 times per month on composite effluent, maximum effluent and influent samples. *Settleable Solids (SS):* Collected 1 to 2 times per week on effluent and influent samples. *In-hatchery Water Temperature* - Daily maximum and minimum readings.

Section 5. Facilities

5.1 Broodstock collection facilities (or methods).

Broodstock will be collected at Lyle Falls, Castile Falls, and (possibly) the Klickitat River Hatchery. Adult fish used for broodstock will be collected randomly from the run-at-large to ensure that the entire run-timing is incorporated into the hatchery. No more than 25% of the natural run will be used as hatchery broodstock in a given brood year.

5.2 Fish transportation equipment (description of pen, tank, truck, or container used).

Adults transported following YKFP Roza Trap/CESRF Protocols (Hager and Costello 1999)

5.3 Broodstock holding and spawning facilities.

All adults trucked or volitionally entering traps are held till maturity in the adult holding pond. These fish are inoculated up to three times during holding with Erythromycin to retard BKD. All fish are spawned directly from the holding pond and resulting eggs are fertilized and transported to the hatchery building. Each female is sampled for BKD levels and the resulting eggs are incubated separately until ELISA results are known.

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Available Flow (gpm)
1	Concrete	9,600	40	60	4	1,400

5.4 Incubation facilities.

Incubator Type	Units (number)	Flow (gpm)	Volume (cu.ft.)	Loading-Eyeing (eggs/unit)	Loading-Hatching (eggs/unit)
FAL	325	184	NA	4,000	6,500

5.5 Rearing facilities.

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Flow (gpm)	Max. Flow Index	Max. Density Index
11	Concrete	3,500	100	10	3.5	250	NA	NA
1	Hypolon Release Pond	29,925	190	45	3.5	55	NA	NA
1	Earthen release pond	24,500	175	40	3.5	6,000	NA	NA

5.6 Acclimation/release facilities.

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Flow (gpm)	Max. Flow Index	Max. Density Index
11	Concrete	3500	100	10	3.5	250	1.85	.20
1	Hypolon Release Pond	29925	190	45	3.5	55	Na	Na
1	Earthen release pond	24500	175	40	3.5	6000	Na	Na

5.7 Describe operational difficulties or disasters that led to significant fish mortality.

None reported for this program.

5.8 Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

Potential Hazard	Risk Aversion Measure
Equipment failure/Water loss	Multiple water sources are available. There is a main river gravity water feed system, three torpedo type river pumps, and several springs available. Backup generator system is automatic in case of power loss. All Pumps are screened.
Flooding/Water Loss	The facility is sited to minimize the risk of catastrophic fish loss from flooding and set up with low water alarm probes in strategic locations to prevent fish loss due to loss of water. Alarm systems are monitored 24/7 with staff available on-station to respond to problems.
Disease Transmission	USFWS fish health guidelines are followed. Fish Health Specialists conduct inspections monthly and problems are managed promptly to limit mortality and reduce possible disease transmission.

Section 6. Broodstock Origin and Identity

6.1 Source.

Broodstock to be used in the program are trapped from the run-at-large at Lyle Falls, Castile Falls, and the Klickitat River Hatchery adult trap. The 200,000 fish released above Castile Falls will be the offspring of 100% NOR adults. The 600,000 juvenile on-station release will come from 100% HOR adults.

6.2.1 History.

Broodstock Source	Origin	Year(s) Used	
		Begin	End
Klickitat Spring Chinook	H	1988	

Broodstock used in the program since 1988 originated from adults returning to the Klickitat Hatchery trap. No other source of broodstock has been used since that time. Klickitat origin adults will continue to be used as hatchery broodstock into the future.

6.2.2 Annual size.

The average annual natural return to the Klickitat basin is 592 (range 65-2227) for 1977-2005 return years. The broodstock collection goal is 722 fish (50% males, 50% females).

6.2.3 Past and proposed level of natural fish in the broodstock.

Historically, only marked fish were used as broodstock. However, with integration of this program, 140 wild (adipose present) Chinook will be used for broodstock beginning in 2009. Based on the recent 10-year average (1996-2005) of NOR spring Chinook returning to the mouth of the Klickitat (925), 15.1% of the natural run will be taken for broodstock. Because spring Chinook eggs may need to be culled to reduce BKD levels, more natural-origin adults may be needed for broodstock. If culling is necessary, no more than 25% of the natural run would be collected and incorporated into the hatchery program.

6.2.4 Genetic or ecological differences.

The genetic divergence found between the Klickitat River wild spring Chinook population and the Klickitat Hatchery population suggests either some amount of reproductive isolation between the two or the possibility that some natural or production-related factors are maintaining differentiation despite exchange of spawners (Marshall 2000). Future broodstock collection will minimize these genetic differences by incorporating more NOR adults into the program (YN 2008).

6.2.5 Reasons for choosing.

Fish propagated through the program represent the indigenous Klickitat River spring Chinook population which is assumed to possess the biological attributes adapted to the Klickitat River.

6.3 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices.

- Adult trapping is monitored daily for incidental capture of listed steelhead and bull trout; ESA-listed fish are identified and quickly returned to the river.
- The new Lyle Falls fish ladder and trapping facility will be designed to meet NMFS fish handling criteria which should reduce adverse impacts to listed fish.

Section 7. Broodstock Collection

7.1 Life-history stage to be collected (adults, eggs, or juveniles).

Adults

7.2 Collection or sampling design

Adults are captured by traps that are in operation from late March through August. Adults volunteering into the hatchery facility may also be used as broodstock. Broodstock will be collected randomly from the run at large over this time period.

7.3 Identity.

Only one natural population. All hatchery fish will be marked with an adipose fin clip or an elastomer tag. A subset of the juveniles will also be coded-wire-tagged.

7.4 Proposed number to be collected:

7.4.1 Program goal (assuming 1:1 sex ratio for adults):

722 adults at a 1:1 female to male ratio.

7.4.2 Broodstock collection levels for the last twelve years (e.g. 1990-2003), or for most recent years available.

Year	Adults			
	Females	Males	Jacks	Eggs
Planned	250	250	Na	
1995	288	196	1697	947,000
1996	346	204	57	1,137,400
1997	603	226	6	1,837,000
1998	218	102	55	764,200
1999	265	210	342	880,280
2000	644	321	48	1,582,100

2001	271	138	352	1,006,900
2002	434	230	213	1,636,000
2003	267	233	23	1,138,800
2004	982	584	871	1,087,750
2005	262	233	317	903,275
2006	361	330	95	1,274,350

7.5 Disposition of hatchery-origin fish collected in surplus of broodstock needs.

Surplus hatchery fish will be distributed to tribal members or released back to the river to support local fisheries. If fish are released back to the river, care will be taken to maintain the proper proportion of hatchery fish on the spawning grounds.

7.6 Fish transportation and holding methods)

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Available Flow (gpm)
1	Concrete	9,600	40	60	4	1,400

Spring Chinook broodstock collected are held to maturity in holding ponds at the Klickitat River Hatchery. Fish are held in a combination of spring, well, and river water. Fish are monitored for pre-spawning mortality which historically has been less than 12%. Adults will be injected with Erythromycin-200 at a dosage of 20-30 mg/kg of body weight upon capture and may receive additional treatments during holding in the even of disease outbreaks.

The transport protocols defined in Hager and Costello (1999) will be followed. Transport time from trapping facilities to the adult holding ponds will be less than 1 hour.

7.7 Describe fish health maintenance and sanitation procedures applied.

Adults will be injected with Erythromycin-200 at a dosage of 20-30 mg/kg of body weight upon capture (Hager and Costello 1999).

7.8 Disposition of carcasses.

The carcasses of adult fish that had 21 days to metabolize erythromycin injections prior to spawning will be planted into local streams to increase nutrients. Carcasses of fish injected within 21-days of spawning will be buried in a locally identified upland landfill.

7.9 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program.

All trapped listed species are identified and returned to the river. Trapping facilities are designed to NMFS criteria to minimize handling stress and mortality.

Section 8. Mating

8.1 Selection method.

Cohorts are used from the entire run cycle with males and females available on a given day mated randomly,. This practice is applicable to both NOR- and HOR- designated spring Chinook populations.

8.2 Males.

Males will be used to achieve a 1:1 spawning ratio whenever possible. Jacks will be represented based on the proportion of jacks observed in the wild population.

8.3 Fertilization.

Eggs are mixed with milt and water hardened with iodophor at a 1:600 concentration. The carcass of each female spawned is individually numbered and the eggs are kept separate from all other females. Each carcass is sampled for BKD levels and eggs are not co-mingled until the ELISA results are known and segregation on BKD levels is possible. Moderate to High ELISA groups will be culled and destroyed.

8.4 Cryo-preserved gametes.

Cryo-preserved gametes are not used.

8.5 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

Broodstock are selected at random from throughout the wild spring Chinook run. Spawning is done randomly based on availability of ripe fish. Matings are done on a 1:1 sex ratio, i.e. one male and one female. Factorial matings of 2x2 crosses will be utilized to prevent genetic population impacts. DNA samples will be collected from both the natural and hatchery components of the run to track to detect changes in allele frequency or presence.

Section 9. Incubation and Rearing.

9.1.1 Number of eggs taken and survival rates to eye-up and/or ponding.

Historical estimates of egg take and survival rates are presented below. The new program, at full implementation, will take on average 950,000 eggs.

Year	Egg Take	Green-Eyed Survival (%)	Eyed-Ponding Survival (%)	Egg Survival Perfor-mance Std.	Fry-fingerling Survival (%)	Rearing Survival Perfor-mance Std.	Fingerling-Smolt Survival (%)
1995	947,000	95	97.60	NA	95.10	NA	96.00
1996	1,137,400	97.50	98.60	NA	97.30	NA	85.85
1997	1,837,000	98.20	99	NA	97.20	NA	81.11
1998	764,200	95.30	98.70	NA	96.20	NA	86.36
1999	880,280	96.10	99	NA	97.10	NA	95.22
2000	1,582,100	96	97.25	NA	98	NA	93.70
2001	1,006,900	96.59	92.30	NA	98.45	NA	90.2
2002	1,636,000	97.85	92.30	NA	99.4	NA	86.0
2003	1,138,800	98.16	89.68	NA	98.7	NA	94.9
2004	**1,087,750**	94.29	92.22	NA	97.9	NA	95.3
2005	903,275	94.67	92.43	NA	99.8	NA	NA
2006	1,274,350	96.48	92.39	NA	NA	NA	NA

NA = Not available

9.1.2 Cause for, and disposition of surplus egg takes.

Surplus eggs may result from unexpected variability in female fecundity or pre-spawn survival rates. Surplus eggs from NOR adults will be incorporated into the on-station release for that year. Surplus eggs from HOR origin fish will be destroyed and buried in the landfill.

9.1.3 Loading densities applied during incubation.

FAL vertical incubators are used for eyeing and hatching spring Chinook eggs at the Klickitat Hatchery. Eggs are loaded at the rate of the eggs from one female per tray to eyeing, and 6,500 eggs per tray for hatching. Average egg size is approximately 1,500 eggs per pound, with a great deal of variation expected.

9.1.4 Incubation conditions.

Integrated Hatchery Operations Team (IHOT) species-specific incubation recommendations are followed for water quality, flows, temperature, substrate and incubator capacities. Harmful silt and sediment is cleaned from incubation systems regularly while eggs are monitored to determine fertilization and mortality. Incubation water is from a spring source and temperature is monitored by thermograph and recorded and temperature units (TU) are tracked for embryonic development. Dissolved oxygen content is monitored and have been at acceptable levels of saturation with a minimum criteria of 8 parts per million (ppm). When using artificial substrate, vexar or bio-rings, egg densities within incubation units are reduced by 10%.

9.1.5 Ponding.

Spring Chinook fry are ponded in up to 11 raceways and reared from December through May of the following year. Fry are ponded when 1) a visual inspection of the amount of yolk sac remaining shows the yolk slit closed to approximately 1 millimeter wide (approximately 1,600 TUs) or based on 95% yolk absorption KD factor. At this time, fry are transferred to the appropriate starter raceway usually during the last two weeks of January.

9.1.6 Fish health maintenance and monitoring.

IHOT and USFWS fish health guidelines are followed. Hatchery staff will conduct daily inspection, visual monitoring, and sampling from eye, fry fingerling, and sub-yearling life stages. As soon as potential problems are seen, these concerns are immediately communicated to the Fish Health Specialist. In regular monitoring, Fish Health Specialists conduct inspections monthly. Potential problems are managed promptly to limit mortality and reduce possible disease transmission.

9.1.7 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation.

IHOT and USFWS fish health guidelines are followed. Eggs in the Klickitat program are on spring water to maximize egg survival and minimize loss from disease. All eggs brought to the facility (for other programs) are surface-disinfected with iodophore (as per disease policy). All equipment (nets, tanks, boots, etc.) is disinfected with iodophore between different fish/egg lots. Different fish/egg lots are physically isolated from each other by separate ponds or incubation units. The intent of these activities is to prevent the horizontal spread of pathogens by splashing water. Foot baths containing disinfectant are strategically located on the hatchery grounds to prevent spread of pathogens. The incubation room units are protected by separate low water alarms.

9.2.1 Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years (1995-2006), or for years dependable data are available.

Year	Egg Take	Green-Eyed Survival (%)	Eyed-Ponding Survival (%)	Fry-fingerling Survival (%)	Fingerling-Smolt Survival (%)
1995	947,000	95	97.60	95.10	96.00
1996	1,137,400	97.50	98.60	97.30	85.85
1997	1,837,000	98.20	99	97.20	81.11
1998	764,200	95.30	98.70	96.20	86.36
1999	880,280	96.10	99	97.10	95.22
2000	1,582,100	96	97.25	98	93.70
2001	1,006,900	96.59	92.30	98.45	90.2
2002	1,636,000	97.85	92.30	99.4	86.0
2003	1,138,800	98.16	89.68	98.7	94.9
2004	1,087,750	94.29	92.22	97.9	95.3
2005	903,275	94.67	92.43	99.8	NA
2006	1,274,350	96.48	92.39	NA	NA

NA = Not available

9.2.2 Density and loading criteria (goals and actual levels).

The juvenile rearing density and loading guidelines used at the facility are based on: standardized agency guidelines, life-stage specific survival studies conducted at other facilities and staff experience. IHOT standards are followed for: water quality, alarm systems, predator control measures to provide the necessary security for the cultured stock, and monitoring of loading and density.

Raceway and pond loading use a flow index of <1.85 (lbs/length/flow) and a density index of 0.2 (length/lbs/volume).

9.2.3 Fish rearing conditions.

NOR fish are reared in raceways 8, 9 and 10, and transferred off-site to upper Klickitat River Basin acclimation ponds for final rearing and volitional release. Production of the HOR yearling cycle takes place in ponds 24 and 26 until release. Temperature, dissolved oxygen and pond turn over rate are monitored. IHOT standards are followed for: water quality, alarm systems, predator control measures (netting) to provide the necessary security for the cultured stock, loading and density. Settleable solids, unused feed, and feces are removed regularly to ensure proper cleanliness of rearing containers. Water temperature regimes are the same as in natural environment.

9.2.4 Indicate biweekly or monthly fish growth information (average program performance), including length, weight, and condition factor data collected during rearing, if available.

The daily amount fed is determined by the number of fish in the population and sample weight. Feed is therefore applied at a daily rate ranging from 2.0% of the total population weight per day (fry and small fingerlings) to 0.7% of the total population weight per day (larger fingerlings and smolts). The expected feed conversion efficiency rate is 1.2.

Rearing Period	Length (mm)	Weight (fpp)	Condition Factor	Growth Rate
07.06	94	50.5	1.082	582
08.06	99.8	40.5	1.132	2924
09.06	109.2	29.5	1.183	6127
10.06	116	21.5	1.35	2681
11.06	123.1	18.7	1.307	4579
12.06	124.3	18.1	1.308	3150
01.07	132.7	15.3	1.289	3089

9.2.5 Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available.

Rearing Period	Length (mm)	Weight (fpp)	Condition Factor	Growth Rate
07.06	94	50.5	1.082	582
08.06	99.8	40.5	1.132	2924
09.06	109.2	29.5	1.183	6127
10.06	116	21.5	1.35	2681
11.06	123.1	18.7	1.307	4579
12.06	124.3	18.1	1.308	3150
01.07	132.7	15.3	1.289	3089

9.2.6 Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Rearing Period	Food Type	Application Schedule (#feedings/day)	Feeding Rate Range (%B.W./day)	Lbs. Fed Per gpm of Inflow	Food Conversion During Period
1: 12/27/05-2/13/06	Ewos Micro #1	7	1.6	0.021	0.58
2: 2/13/06-2/28/06	Ewos Micro #2	5	1.8	0.039	0.59
3: 2/28/06-5/8/06	Ewos Pacific 1.2 mm	2	1.8	.029	.60
4: 5/8/06-2/5/07	Ewos Vita 1.5 w/boost	1	1.1	0.06	0.77

9.2.7 Fish health monitoring, disease treatment, and sanitation procedures.

Fish Health Monitoring	Policy guidance includes: *Fish Health Policy in the Columbia Basin*. Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995). A Fish Health Specialist inspects fish programs at Klickitat Complex monthly and checks both healthy and if present, symptomatic fish. Based on pathological or visual signs by the crew, age of fish and the history of the facility, the pathologist determines the appropriate tests. External signs such as lesions, discolorations, and fungal growths will lead to internal examinations of skin, gills and organs. Kidney and spleen are checked for bacterial kidney disease (BKD). Blood is checked for signs of anemia or other pathogens. Additional tests for virus or parasites are done if warranted.
Disease Treatment	As needed, appropriate therapeutic treatment will be prescribed to control and prevent further outbreaks. Yearling spring Chinook receive one prophylactic treatment of pills top coated with erythromycin. Dead fish are collected daily and disposed of at an approved landfill. Fish health and or treatment reports are kept on file.
Sanitation	All eggs brought to the facility are surface-disinfected with iodophor (as per disease policy). All equipment (nets, tanks, boots, etc.) is disinfected with iodophor between different

	fish/egg lots. Different fish/egg lots are physically isolated from each other by separate ponds or incubation units. The intent of these activities is to prevent the horizontal spread of pathogens by splashing water. Tank trucks are disinfected between the hauling of adult and juvenile fish. Footbaths containing disinfectant are strategically located on the hatchery grounds to prevent spread of pathogens.

9.2.8 Smolt development indices (e.g. gill ATPase activity), if applicable.

The migratory state of the release population is determined by fish behavior. Aggressive screen and intake crowding, swarming against sloped pond sides, leaner condition factors, a more silvery physical appearance and loose scales during feeding events are signs of smolt development. Multiple smolt events can also be triggered by environmental cues including daylight increase, a spike in the water temperature and spring freshets.

Starting with the releases in 2009, juvenile ATP-ase activity will be monitored to better identify the onset of smoltification and establish release schedule.

9.2.9 Indicate the use of "natural" rearing methods as applied in the program.

Rearing methods and techniques found to be effective at the CESRF will be incorporated into this program as they become proven.

9.2.10 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation.

Limit out-of-basin transfers of fish or eggs for use as broodstock, except in rare circumstances. Reduces risk of disease introductions to Subbasin.

Protocols for population size, fish health disinfection and genetic guidelines followed.

USFWS and IHOT hatchery guidelines are followed for rearing, release, and fish health parameters.

Section 10. Release

10.1 Proposed fish release levels.

Age Class	Max. No.	Size (ffp)	Release Date	Location			
				Stream	Release Point (RKm)	Major Water-shed	Eco-province
Yearling	800,000	12-15	March	Klickitat	68	Klickitat	Columbia Gorge

10.2 Specific location(s) of proposed release(s).

The 800,000 on-station group will be volitionally released from Ponds 24-26 at the Klickitat hatchery (RKm 68) in March.

10.3 Actual numbers and sizes of fish released by age class through the program.

Release Year	Fingerling Release			Yearling Release		
	No.	Date (MM/DD)	Avg Size (fpp)	No.	Date (MM/DD)	Avg Size (fpp)
1996	223000	5/28-5/29	54	610000	2/8-2/9;3/1-3/16	6
1997	382500	5/27-5/29	49.5	580600	3/1-3/15	7
1998	343380	5/6, 5/7, 6/30	77	584500	3/2-3/12	7
1999	40600	5/11	81	538000	3/1, 3/2	7.5
2000	190842	5/2,5/3,8/9,8/17	63.6	562000	3/1-3/10, 3/20-3/31	6.4
2001	252098	5/13, 7/22	51.4	615000	3/7-3/9	7.7
2002	223298	5/13	51.4	605000	3/8-3/10	7.7
2003	286,400	5/6,8/6	71/36	607500	3/5-3/8	8.0
2004	348,910	4/4, 5/10	70/60	609,800	3/1 – 3/5	13.7
2005	269,800	5/5 – 5/17	68	628,196	3/1 – 3/7	14.5
2006	155,230	5/21, 6/12, 7/12	58/68/56	607,900	3/6 – 3/10	14.1

10.4 Actual dates of release and description of release protocols.

See above

10.5 Fish transportation procedures, if applicable.

NA

10.6 Acclimation procedures (*methods applied and length of time*).

10.7 Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.

All spring Chinook released from the Klickitat Hatchery will receive an adipose clip; 17% of fish in all release groups will also be coded-wire-tagged.

10.8 Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

Surplus NOR juveniles will be transported and released above Castile Falls. All surplus HOR-origin juveniles will also be released on-site. However, before the surplus juveniles are released, the Hatchery Complex Manager will contact the Senior Fisheries Biologist to apprise him/her of the situation. He then consult will with appropriate regional co-managers/NOAA to get recommendations for fish disposition. The Hatchery Complex Manager will instruct hatchery personnel to implement the recommendation.

10.9 Fish health certification procedures applied pre-release.

Prior to release, fish are given a fish health exam. If abnormal behavior or mortality is observed, the staff contacts the Area Fish Health Specialist. The Fish Health Specialist examines affected fish and recommends the appropriate treatment. Reporting and control of fish pathogens are done in accordance with the Co-managers' Fish Disease Control Policy. All fish are examined for the presence of "reportable pathogens" as defined in the PNFHPC disease control guidelines, within 1 to 3 weeks prior to release (http://www.fws.gov/pnfhpc/).

10.10 Emergency release procedures in response to flooding or water system failure.

If the program is threatened by ecological or mechanical events, the Complex Manager will contact and inform regional management of the situation. Based on a determination of a partial or complete emergency release of program fish, if an on-station emergency release is authorized, personnel will pull screens and sumps and fish will be force-released into the Klickitat River. No release of fish will occur without a review by YN Fisheries Management.

In the event of a water system failure, screens will be pulled to allow fish to exit the ponds. In some cases, fish can be transferred into other rearing vessels to prevent an emergency release. The YN also has emergency response procedures for providing back-up pumps, transport trucks, etc. In cases of severe flooding, the screens will not be pulled. Past experience has shown that the fish tend to stay on the bottom of the pond during flooding events; the only fish that leave are those that are inadvertently swept out.

10.11 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases.

- The program calls for production and release of smolts only. Fish culture practices and volitional releases encourage rapid seaward migration with minimal rearing or delay in the rivers. This will limit interactions with naturally produced steelhead and bull trout juveniles.
- YN fish health and operational concerns for Klickitat Hatchery programs are regularly communicated to USFWS and other co-managers for risk management or needed treatment.

Section 11. Monitoring and Evaluation of Performance Indicators

11.1 Monitoring and evaluation of "Performance Indicators presented in Section 1.10.

11.1.1 Describe plans and methods proposed to collect data necessary to respond to each "Performance Indicator" identified for the program.

Harvest Contribution: A portion of all hatchery releases will be tagged with a CWT so that harvest rates in both ocean and freshwater fisheries can be tracked. Additionally, the YN and WDFW monitor and track tribal and sport harvest in the Klickitat River to develop estimates of in-river harvest levels.

Straying: A portion of the hatchery fish releases will be tagged with elastomer and CWT tags. Regional sampling protocols call for the collection and reporting of cwt's to the RMIS database. YN staff will query this database for tags captured outside of the Klickitat River. CWT fish located in basins outside of the Klickitat will be considered as strays. Additionally, YN staff will request all agencies conducting fish run research or monitoring to report any elastomer tags found.

Smolt-to-Adult Survival (SAR): SAR values will be calculated by surveying for tagged fish in ocean and freshwater fisheries, spawning surveys, and broodstock collection facilities.

PNI: Spawning and carcass surveys will be used to document the number and proportion of hatchery fish on the spawning grounds. In addition, the proportion of the NOR run used as broodstock will also be monitored at the hatchery. These two pieces of data will be used to calculate a PNI value for the composite stock (hatchery and natural).

Water Diversion Screens: Facility water intakes will be designed in accordance with NMFS standards. Velocity measurements will be taken at each screening system each year to ensure the criteria are being met. Screens will also be inspected each year for any problems (missing panels, debris, etc.) and corrective actions taken.

Hatchery Operations: An annual report will be written documenting program operations, disease problems, treatment, broodstock collection, number of fish released, fish size, and release date.

11.1.2 Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Staff and funding levels as outlined in the Klickitat River Anadromous Fisheries Master Plan (in draft) should be sufficient to implement the M&E program.

11.2 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from monitoring and evaluation activities.

Survey techniques used to monitor adult spawning in the natural environment and estimate PNI are designed to minimize disturbance to active steelhead spawners.

Section 12. Research

12.1 No research activities are proposed for spring Chinook that will affect listed fish populations in the Klickitat River.

Section 13. Attachments and Citations

13.1 Attachments and Citations:

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Section 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

14.1 Certification Language and Signature of Responsible Party

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by______________________________ Date:_____________

Section 15

ADDENDUM A. PROGRAM EFFECTS ON OTHER (AQUATIC OR TERRESTRIAL) ESA-LISTED POPULATIONS

15.1) List all ESA permits or authorizations for USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species associated with the hatchery program.

No permits in place for this new program. They will be developed through consultation with appropriate agencies as facilities and programs are developed.

15.2) Describe USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species and habitat that may be affected by hatchery program.

Hatchery operations may impact federally listed Klickitat River bull trout (*Salvelinus confluentus*). Bull trout are listed as Threatened by the USFWS. The USFWS has designated the West Fork Klickitat River and Klickitat River reaches adjacent to the Yakama Indian Reservation as Critical Habitat (Federal Register 2005). Stream habitat in the Klickitat River Subbasin has been impacted by human activities associated with agriculture, logging, recreation, and urban development.

Hatchery facilities are located both within and near the Klickitat River. Water for rearing anadromous fish at the Klickitat River hatchery is diverted from the river. New juvenile acclimation sites are being developed at the Wahkiacus Hatchery (RKm 27) that will disturb upland and riparian habitat near the stream channel. A diversion structure will also be built at this facility to provide water for acclimating hatchery smolts.

Other listed or candidate species that may be impacted by the construction and operation of the Wahkiacus Hatchery and Acclimation Facility Creek include:

Oregon Spotted Frog (*Rana pretiosa*)	Candidate
Bald Eagle (*Haliaeetus leucocephalus)*	Threatened
Northern Spotted Owl (*Strix occidentalis)*	Threatened

The possible impacts from the construction and operation of new facilities have not been quantified.

15.3) **Analyze effects.**

Bull Trout

Possible hatchery operational effects on listed bull trout in the Klickitat River are described below. The effects are expected to be on-going while the hatchery program remains in place.

Water diversion: Water is diverted from the Klickitat River to operate the Klickitat River Hatchery. This action may result in a slight decrease in the amount of habitat (0.25 miles of stream) and quality of stream habitat that will be de-watered. The loss in habitat may result in a decrease in bull trout abundance. However, because bull trout are primarily found in the West Fork Klickitat River and tributaries higher in the Subbasin than the location of the hatchery, impacts to bull trout are expected to be minor. Currently, data are unavailable to support this assumption.

Diversion Screens: The Klickitat River Hatchery water intakes will be screened to meet NMFS criteria for fry. Impacts to juvenile bull trout are expected to be minor, if at all.

Waste and Pollutants: The facility will under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). The limitations listed in the permit are assumed to be protective of water quality and therefore the hatchery waste water is likely to have little impact on bull trout.

Disease: Outbreaks in the hatchery may cause significant adult, egg, or juvenile mortality. Over the years, rearing densities, disease prevention, and fish health monitoring have greatly improved the health of fish in the programs at the Klickitat River Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the populations' health. The level of indirect take of bull trout from disease is unknown.

Broodstock Collection: Broodstock will be collected at Lyle Falls, Castile Falls and the Klickitat River Hatchery. Trapping facilities will be designed in accordance with NMFS criteria; impacts to listed fish species will be minimal.

Release of Juveniles: The program will release 800,000 spring Chinook into the Klickitat River each year. These fish may compete with and prey on juvenile bull trout. Smolt length at release will range from 139 to155 mm. NMFS and USFWS postulate that smolts consume prey whose length is 33% of the smolts' body length. It is expected that hatchery spring Chinook released at 139 to 155 mm could prey upon juvenile bull trout that are 46 to 51 mm in length. However, because almost all juvenile bull trout production is located in the West Fork Klickitat River, hatchery spring Chinook released in the mainstem Klickitat River are unlikely to encounter juvenile bull trout.

Food: The carcasses of naturally spawning spring Chinook adults returning to the Subbasin may increase stream productivity through the addition of ocean-derived nutrients. Increased productivity may result in an increase in food availability to both juvenile and adult bull trout. Offspring of naturally spawning coho may also provide a food source for bull trout.

Monitoring and Evaluation: Smolt trapping may be used to determine that hatchery spring Chinook juveniles migrate quickly through the system after release. Some bull trout may be captured and handled at the trapping facilities.

Oregon Spotted Frog

Neither construction nor operations of hatchery facilities are likely to impact this species. The only known population of Oregon Spotted Frog in the Klickitat River Subbasin is located in the Conboy Lake National Wildlife Refuge (NWR) managed by USFWS (Klickitat Subbasin Plan 2002). The refuge is located approximately 10 miles east of Trout Lake and 7 miles southwest of Glenwood in the Glenwood Valley/Camas Prairie area.

Bald Eagle

Bald eagles can be found throughout the year in the Klickitat River Subbasin. Because bald eagles feed on salmon, increased hatchery production should result in an increase in food for this species as a result of more adult fish returning to the Subbasin. Eagles could experience disturbance during some hatchery activities such as fish transport, but the effect is expected to be short-term and minor in nature.

Northern Spotted Owl

No facilities will be located in nor activities conducted in areas inhabited by the Northern Spotted Owl or in suitable owl habitat.
.

15.4 Actions taken to minimize potential effects.

Bull trout

Diversion Screens: All intake screens will be built or updated to meet NMFS screen criteria for fry.

Waste and Pollutants: All terms and conditions associated with the NPDES Permit will be implemented and followed.

Broodstock Collection: Broodstock collection facilities will be designed to USFWS and NMFS standards thereby reducing the probability that bull trout will be harmed if collected in these facilities.

Monitoring and Evaluation: Bull trout collected during juvenile trapping operations will be released unharmed to the stream.

Oregon Spotted Frog

Prior to constructing new facilities or upgrading existing facilities, the stream and riparian areas near proposed sites will be surveyed for the presence of the Oregon Spotted Frog. If this species is found, YN will coordinate with USFWS staff to develop mitigation and protection measures.

Bald Eagle

New facilities will not be located near bald eagle nests.

Northern Spotted Owl

No facilities are located in Northern Spotted Owl habitat; no impacts are expected.

15.5 References

IHOT (Integrated Hatchery Operations Team). 1995. Operation plans for anadromous fish production facilities in the Columbia River basin. Volume III-Washington. Annual Report 1995. Bonneville Power Administration, Portland Or. Project Number 92-043. 536 pp.

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Yakama Nation 2008. *Draft* Klickitat River Anadromous Fisheries Master Plan, Yakima/Klickitat Fisheries Program. Toppenish, WA.

Appendix 1- Take Tables

Estimated listed salmonid take levels by hatchery activity.

Steelhead

ESU/Population	Middle Columbia River Steelhead
Activity	Klickitat Hatchery Spring Chinook Program
Location of hatchery activity	Klickitat R. Hatchery
Dates of activity	May – September
Hatchery Program Operator	WDFW

Type of Take	Annual Take of Listed Fish by life Stage (number of fish)			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass (a)				
Collect for transport (b)				
Capture, handle, and release (c)		5,000	50*	
Capture, handle, tag/mark/tissue sample, and release (d)				
Removal (e.g., broodstock) (e)				
Intentional lethal take (f)				
Unintentional lethal take (g)				
Other take (indirect, unintentional) (h)				

*- Although steelhead have not been taken during past hatchery activities, it is anticipated that a few adult will be collected and handled at the new Castile Falls and Lyle Falls collection facilities. No mortality is expected from these operations. Past trapping activities, conducted as part of M&E for juvenile traps, indicates that approximately 5,000 juvenile steelhead may be handled annually.

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled, and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category

Take Table 2. Estimated listed salmonid take levels by hatchery activity.

Bull Trout

ESU/Population	Columbia River Basin DPS Bull Trout
Activity	Klickitat Hatchery Spring Chinook Program
Location of hatchery activity	Klickitat R. Hatchery
Dates of activity	May – September
Hatchery Program Operator	WDFW

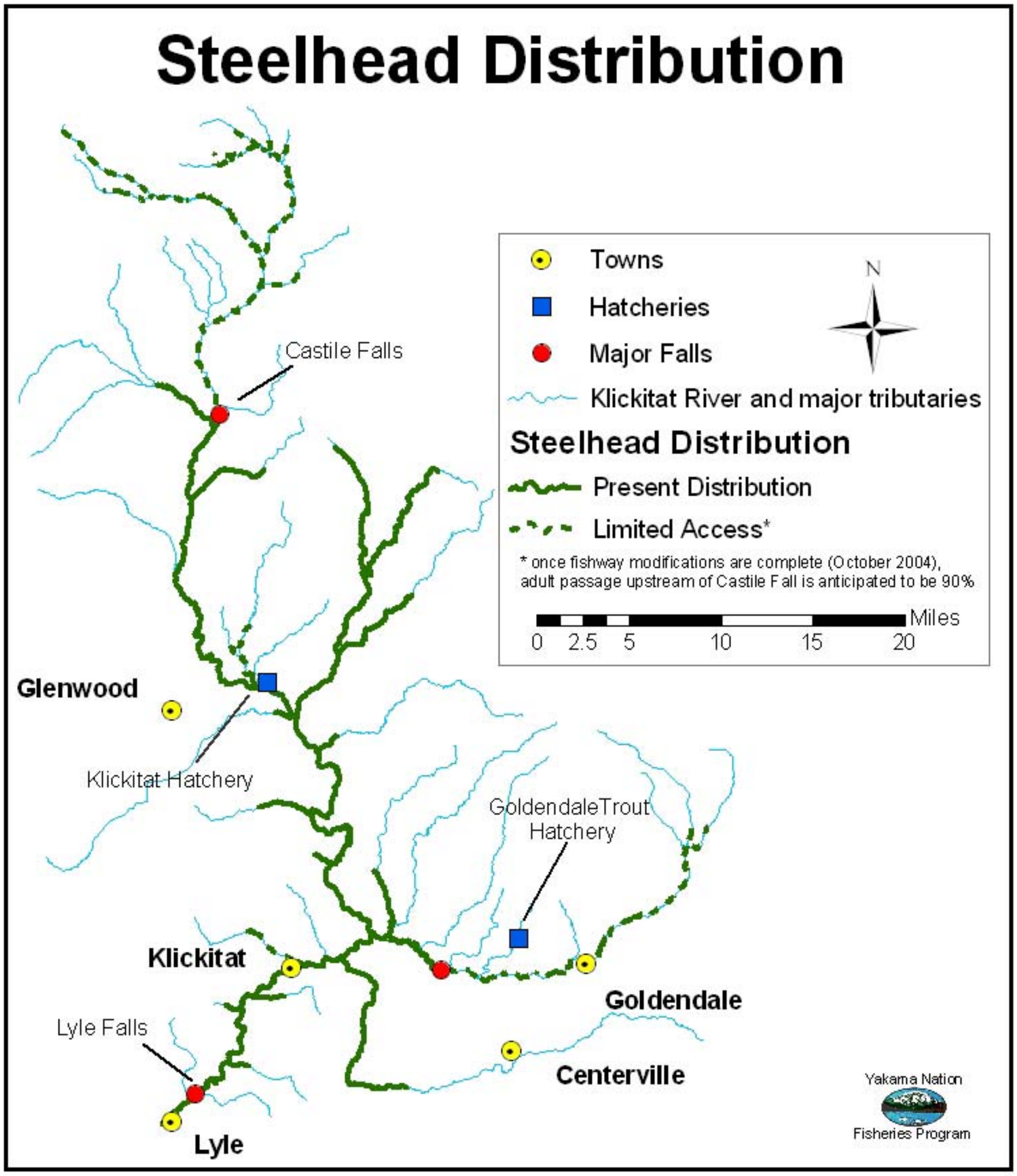
Type of Take	Annual Take of Listed Fish by life Stage (number of fish)			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass (a)				
Collect for transport (b)				
Capture, handle, and release (c)			0*	
Capture, handle, tag/mark/tissue sample, and release (d)				
Removal (e.g., broodstock (e)				
Intentional lethal take (f)				
Unintentional lethal take (g)				
Other take (indirect, unintentional) (h)				

* Bull Trout have not been observed in hatchery operations.

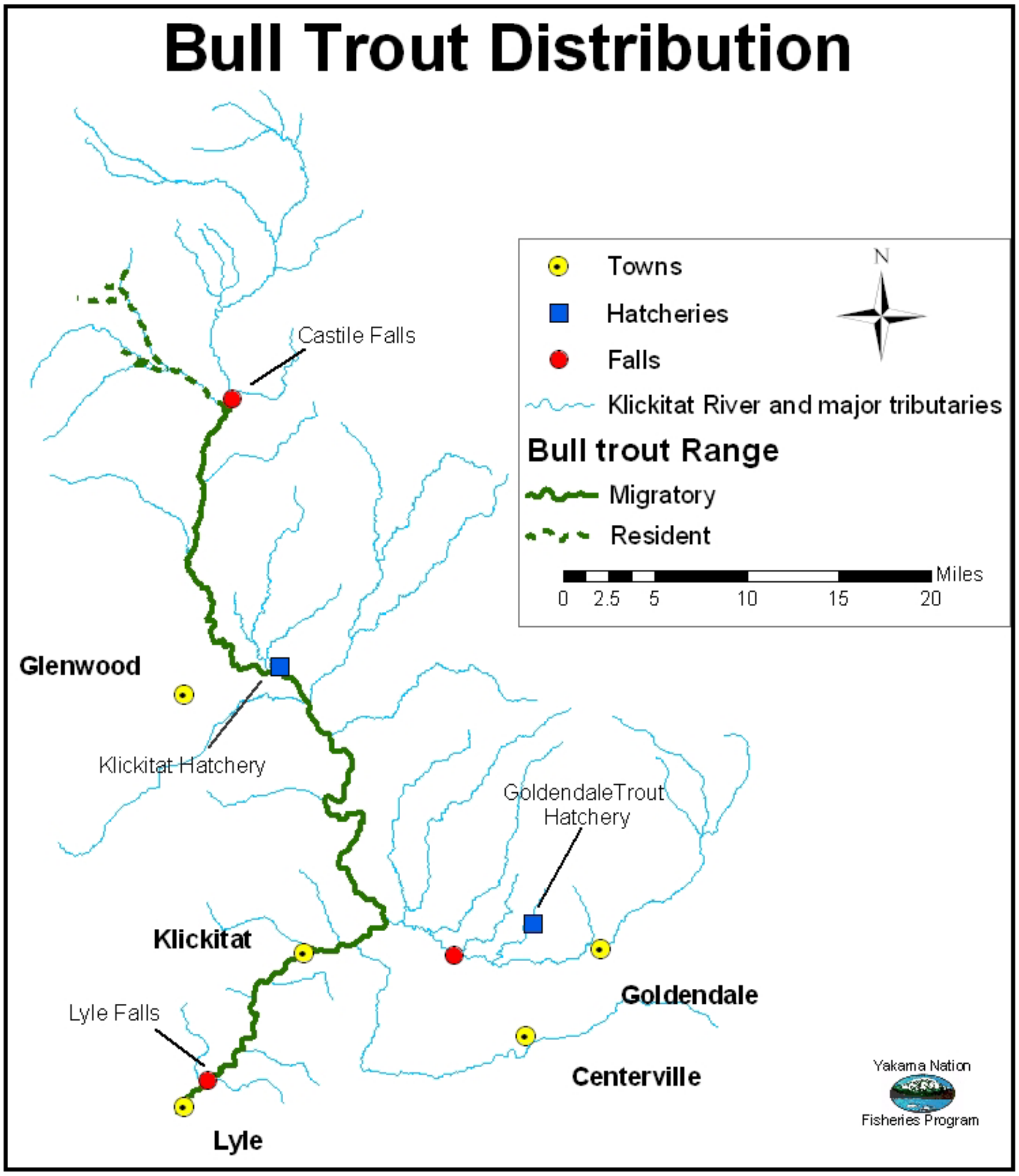
a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled, and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category

Appendix A- Steelhead and Bull Trout Distribution

Steelhead Distribution



Bull Trout


Bull Trout Distribution
Towns
Hatcheries
Falls
Klickitat River and major tributaries
Bull trout Range
Migratory
Resident
N
Miles
0 2.5 5 10 15 20
Castile Falls
Glenwood
Klickitat Hatchery
GoldendaleTrout Hatchery
Klickitat
Goldendale
Lyle Falls
Centerville
Lyle
Yakama Nation
Fisheries Program

Klickitat Hatchery Coho

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HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Final Draft

Hatchery Program	*Klickitat Hatchery Coho*
Species or Hatchery Stock	*Oncorhynchus kisutch "Type N" Coho Salmon*
Agency/Operator	*Yakama Nation*
Watershed and Region	*Klickitat Subbasin/Columbia Gorge Province*
Date Submitted	*February 2008*
Date Last Updated	*February 2008*

Section 1: General Program Description

1.1 Name of hatchery or program.

Wahkiacus Hatchery (Klickitat River) Type N Coho

1.2 Species and population (or stock) under propagation, and ESA status.

Type N Coho (*Oncorhynchus kisutch*)

ESA Status: Not listed

1.3 Responsible organization and individuals.

Name (and title):	Jason Rau (Klickitat Complex Manager)
	Bill Sharp (YKFP Klickitat Coordinator)
Agency or Tribe:	Yakama Nation
Address:	PO Box 151 Toppenish WA 98948
Telephone:	(509) 865-5121
Fax:	(509) 865-6293
Email:	jayrau@ykfp.org sharp@yakama.com

Other agencies, Tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program.

Co-operators	Role
National Marine Fisheries Service (NMFS)	Manager of Mitchell Act Funds
United States Fish and Wildlife Service (USFWS)	Fish Health

1.4 Funding source, staffing level, and annual hatchery program operational costs.

Funding Sources
Mitchell Act

Operational Information	Contract Number NA06NMF4360230
Full time equivalent staff	5 existing employees (1-2 new seasonal)
Annual operating cost (dollars)	$87,000 (NPCC Step-1 estimate)

1.5 Location(s) of hatchery and associated facilities.

Broodstock source	Klickitat River
Broodstock collection location (stream, RKm, subbasin)	Klickitat Hatchery (RKm 68) Wahkiacus Hatchery Acclimation Facility (RKm 27), Lyle Falls (RKm 3.5)
Adult holding location (stream, RKm, subbasin)	Wahkiacus Hatchery Acclimation Facility (RKm 27)
Spawning location (stream, RKm, subbasin)	Wahkiacus Hatchery Acclimation Facility (RKm 27)
Incubation location (facility name, stream, RKm, subbasin)	Washougal River Hatchery
Rearing location (facility name, stream, RKm, subbasin)	Washougal River Hatchery Wahkiacus Hatchery Acclimation Facility (RKm 27)

1.6 Type of program.

Segregated Harvest (Convert to Local Broodstock)

1.7 Purpose (Goal) of program.

- To produce coho salmon to help mitigate for fish losses due to activities, such as federal dam construction, within the Columbia River Basin that have decreased salmonid populations. Coho smolts released into the Klickitat Subbasin are solely for harvest opportunity.
- To benefit sport and tribal fisheries at the mouth of the Klickitat River, in-river sport fisheries, and mixed stock ocean fisheries.
- To rear and release 1,000,000 Type-N coho smolts from Wahkiacus Hatchery Acclimation Facility (WHAF)

1.8 Justification for the program.

- The coho production program is funded through the Mitchell Act via NMFS for the purpose of mitigating for lost fish production due to development within the Columbia River Basin. The “Mitchell Act” (Act) (Public Law 75-502) was passed in 1938.
- Federal Court Decisions (US vs. Oregon and US vs. Washington) ruled that Indian Tribes who signed treaties with the federal government in the 1850s have treaty rights to harvest a share (50%) of surplus fish resources.
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- Pacific Northwest Electric Power Planning and Conservation Act.
- Columbia River Fisheries Development Program

- Columbia River Fish Management Plan

In order to minimize impact on listed fish by YN facilities operation and the Klickitat N coho program, the following Risk Aversion Measures are included in this HGMP:

Summary of risk aversion measures for the Klickitat N Coho program.

Potential Hazard	Risk Aversion Measures
Water Withdrawal	Water rights will be formalized through a trust water right with the Department of Ecology. Monitoring and measurement of water usage will be reported in monthly NPDES reports.
Intake Screening	YN has requested funding for future scoping, design, and construction work of a new river intake system to meet NOAA compliance (Mitchell Act Intake and Screening Assessment 2002).
Effluent Discharge	Both the Klickitat Hatchery and WHAF facilities will be operated under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) administered by the Washington Department of Ecology (DOE) - WAG 13-5002.
Broodstock Collection & Adult Passage	Broodstock will be collected at Wahkiacus, Lyle Falls, and Klickitat Hatchery.
Disease Transmission	*Fish Health Policy in the Columbia Basin*. Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).
Competition & Predation	Coho will be released relatively low in the Klickitat Subbasin at RKm 27. Fish will be released volitionally to foster rapid migration out of the Subbasin. Gill ATP-ase samples will be collected on the juveniles to document smoltification levels.
Harvest	All coho will be marked so that selective fisheries practices will be effective.

1.9 List of program "Performance Standards".

See HGMP Section 1.10

1.10 List of program "Performance Indicators", designated by "benefits" and "risks".

1.10.1 Benefits: Note: Some sections apply to the broodstock program at Washougal Hatchery.

Benefits		
Performance Standard	Performance Indicator	Monitoring & Evaluation
Assure that hatchery operations support Columbia River fish Mgt. Plan *(US v Oregon)*, production and harvest objectives	Contribute to a meaningful harvest for sport, tribal and commercial fisheries. Maintain a combined average annual harvest (ocean, Columbia River, and Klickitat basin) of approximately 14,000 coho.	Survival and contribution to fisheries will be estimated for each brood year released. Work with co-managers to manage adult fish returning in excess of broodstock need.
Smolt-to-Adult Survival (SAR)	Achieve an SAR of 2% to the Klickitat River Subbasin.	SAR will be determined by counting tagged fish recovered at traps, broodstock collection facilities, sport and tribal fisheries and on the spawning grounds.
Adult Straying	Stray rate of less than 5%	Regional M&E efforts will be used to track the number and capture location of Klickitat River- origin fish
Maintain outreach to enhance public understanding, participation and support of YN hatchery programs	Provide information about agency programs to internal and external audiences. For example, local schools and special interest groups tour the facility to better understand hatchery operations. Off-station efforts may include festivals, classroom participation, stream adoptions and fairs.	Evaluate use and/or exposure of program materials and exhibits as they help support goals of the information and education program. Record on-station organized education and outreach events.
Program contributes to fulfilling tribal trust responsibility mandates and treaty rights	Follow pertinent laws, agreements, policies, and executive and judicial orders on consultation and coordination with Native American tribal governments	Participate in annual coordination meetings between the co-managers to identify and report on issues of interest, coordinate management, and review programs (FBD process).
Implement measures for broodstock management to maintain integrity and genetic diversity. Maintain effective population size.	A minimum of 500 adults are collected throughout the spawning run in proportion to timing, age and sex composition of return (Washougal or Lewis River Hatcheries)	Annual run timing, age and sex composition, and return timing data are collected. Adhere to WDFW spawning guidelines. (Seidel 1983) Adhere to WDFW stock transfer guidelines. (WDFW 1991)
Region-wide, groups are marked in a manner consistent with information needs and protocols to estimate impacts to natural and hatchery origin fish	Use mass-mark (100% adipose-fin clip) for selective fisheries with additional groups Ad+CWT (100,000 cwt) for evaluation purposes	Returning fish are sampled throughout their return for length, sex,, and mark
Maximize survival at all life stages using disease control and disease prevention techniques. Prevent introduction, spread or amplification of fish pathogens. Follow Co-managers Fish Health Disease Policy (1998).	Necropsies of fish to assess health, nutritional status, and culture conditions	USFWS Fish Health Section inspect adult broodstock yearly for pathogens at Washougal Hatchery and monitor juvenile fish on a monthly basis to assess health and detect potential disease problems. As necessary, WDFW's Fish Health Section recommends remedial or preventative measures to prevent or treat disease, with administration of therapeutic and prophylactic treatments as deemed necessary A fish health database will be maintained to identify trends in fish health and disease and implement fish health management plans based on findings.

Benefits		
Performance Standard	Performance Indicator	Monitoring & Evaluation
	Release and/or transfer exams for pathogens and parasites.	1 to 6 weeks prior to transfer or release, fish are examined in accordance with the Co-managers Fish Health Policy
	Inspection of adult broodstock for pathogens and parasites.	At spawning, adult broodstock in lots of 60 fish are to be examined for pathogens
	Inspection of off-station fish/eggs prior to transfer to hatchery for pathogens and parasites.	Controls of specific fish pathogens through eggs/fish movements are conducted in accordance with Co-managers Fish Health Disease Policy (WDFW and NWIFC 1998)

1.10.2 Risks:

Risks		
Performance Standard	Performance Indicator	Monitoring & Evaluation
Minimize impacts and/or interactions to ESA listed fish	Hatchery operations comply with all state and federal regulations. Hatchery juveniles are raised to smolt-size (15.0 fish/lb) and released from the hatchery at a time that fosters rapid migration downstream. Mass mark production fish to identify them from naturally produced fish.	Monitor size, number, date of release and mass mark quality.
Artificial production facilities are operated in compliance with all applicable fish health guidelines, facility operation standards and protocols including IHOT, Co-managers Fish Health Policy and drug usage mandates from the Federal Food and Drug Administration	Hatchery goal is to prevent the introduction, amplification or spread of fish pathogens that might negatively affect the health of both hatchery and naturally reproducing stocks and to produce healthy smolts that will contribute to the goals of this facility.	Pathologists from USF&WS Lower Columbia River Fish Health Center monitor program monthly. Exams performed at each life stage may include tests for virus, bacteria, parasites and/or pathological changes, as needed
Ensure hatchery operations comply with state and federal water quality and quantity standards through proper environmental monitoring	NPDES permit compliance YN water right permit compliance	Flow and discharge reported in monthly NPDES reports.
Water withdrawals and in-stream water diversion structures for hatchery facility will not affect spawning behavior of natural populations or impact juveniles.	Hatchery intake structures will meet state and federal guidelines when located in fish-bearing streams.	Barrier and intake structure compliance assessed and needed fixes are prioritized.
Hatchery operations comply with ESA responsibilities	YN completes an HGMP and is issued a federal and state permit when applicable.	Identified in HGMP and Biological Opinion for hatchery operations.
Harvest of hatchery-produced fish minimizes impact to wild populations	Harvest is regulated to meet appropriate biological assessment criteria. Mass mark juvenile hatchery fish prior to release to enable state agencies to implement selective fisheries.	Harvests are monitored by agencies and tribes to provide up to date information.

1.11.1 Proposed annual broodstock collection level (maximum number of adult fish).

Broodstock collection currently occurs at Washougal Hatchery. The program will require about 750 adults. (1:1 Male to Female ratio). Broodstock collection activities will occur in the future at Wahkiacus and Klickitat hatcheries and possibly Lyle Falls.

1.11.2 Proposed annual fish release levels (maximum number) by life stage and location.

Age Class	Max. No.	Size (ffp)	Release Date	Location			
				Stream	Release Point (RKm)	Major Water-shed	Eco-province
Yearling	1,000,000	15.0	May	Klickitat	RKm 27	Klickitat	Columbia Gorge

1.12 Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.

Brood Year	SAR (%)	Total Catch*
1988	1.69	16,562
1989	0.55	5,300
1990	0.13	1,200
1991	0.13	1,200
1992	0.10	980
1993	Na*	Na*
1994	0.07	680
1995	0.01	98
1996	0.01	98
1997	0.06	580
1998	0.47	4,600
1999	0.74	7,200
Avg.	.30%	2,900

Data Source: Annual Coded-Wire Tag Program, Washington Missing Production Group, Annual Report 2000
* data not available

Historically, coho escapement estimates have not been developed.

1.13 Date program started (years in operation), or is expected to start.

The first year of operation for this hatchery was 1951. The *U.S. v. Oregon* Columbia River Fish Management Plan has mandated releases of up to 4.0 million coho in the river annually since 1988.

The conversion to local broodstock is expected to begin in 2009. The actual conversion rate will depend on run-size back to the Subbasin.

1.14 Expected duration of program.

The program is on-going with no planned termination at this time. However, the YN will explore opportunities to eliminate the program if harvest goals can be achieved outside of the Subbasin.

1.15 Watersheds targeted by program.

Klickitat Subbasin/Columbia Gorge Province

1.16 Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.

1.16.1 Potential Alternatives:

The alternatives considered for implementation, but rejected, are presented below. More detailed rationale for rejecting the alternatives can be found in the revised Klickitat River Anadromous Fisheries Master Plan (Yakama Nation 2008, *in draft*).

Alternative 1- Maintain Existing Program: Risks to ESA-listed steelhead and bull trout were not acceptable and can be avoided; therefore this alternative was not selected for implementation.

Alternative 2- Eliminate Program: This alternative does not meet tribal harvest goals and *U.S. v Oregon* agreements and was therefore was not considered for implementation.

Section 2: Program Effects on ESA-Listed Salmonid Populations

2.1 List all ESA permits or authorizations in hand for the hatchery program.

This program is included in the Klickitat River Anadromous Fisheries Master Plan (Yakama Nation 2008 *in draft*). An EIS will be prepared for the Master Plan in 2008. At that time, all hatchery actions will be reviewed and approved by the regulatory agencies.

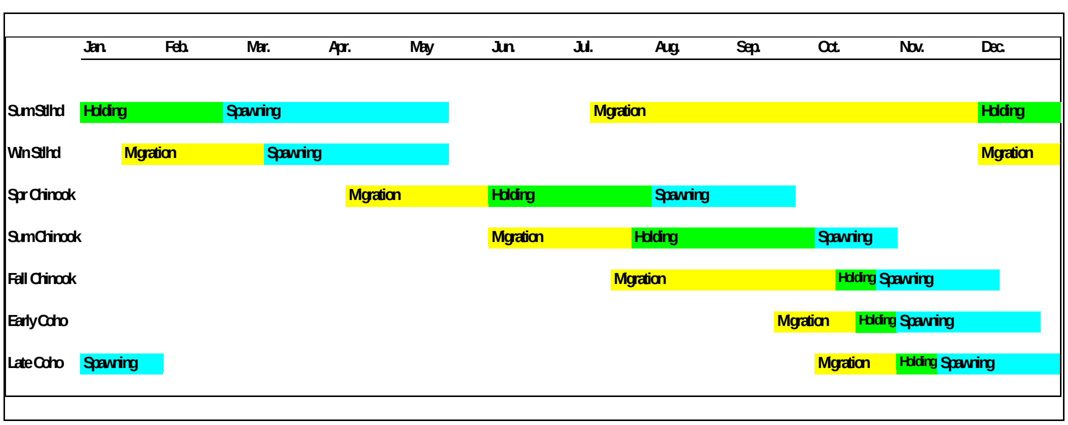
2.2 Descriptions, status and projected take actions and levels for ESA-listed natural populations in the target area.

The following ESA-listed natural salmonid populations occur in the Subbasin where the program fish are released:

ESA-listed stock	Status	Take Level	Action
Summer Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls
Winter Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls
Bull Trout – Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls

2.2.1) Description of ESA-listed salmonid population(s) affected by the program.

Adult and juvenile run-timing for listed steelhead- and other fish species- are presented in the figure below.



The majority of the steelhead population is found from the mouth of the Klickitat River to Castile Falls. Steelhead access to areas above Castile Falls has been limited due to poor natural migration conditions at the falls. Steelhead spawning is concentrated between RKm 8 and 80. Tributary spawning occurs in Swale, Swift, Summit and White Creeks, the lower Little Klickitat River, and other small tributaries.

Klickitat River bull trout life-history characteristics are not well understood. Research is on-going to collect more data on this species. Bull trout are found in the West Fork and many of its tributaries. Electro-fishing work has shown that bull trout in the West Fork are likely resident, based on the size of fish collected (~ 10 inches)**.** Falls on the West Fork likely isolate most of the resident bull trout population from the mainstem Klickitat River.

Based on limited data, it appears that an adfluvial population of bull trout may be present in the lower Klickitat River below Lyle Falls. Additional work is on-going to determine bull trout abundance and distribution in the lower river.

Maps depicting steelhead and bull trout distribution in the Klickitat River are presented in Appendix A.

Identify the ESA-listed population(s) that will be directly affected by the program

No NMFS ESA listed populations will be directly affected by this program.

Identify the ESA-listed population(s) that may be incidentally affected by the program

Middle Columbia River Steelhead March 19, 1998; 64 FR 14508. Threatened
Columbia Basin DPS Bull Trout June 10, 1998 (63 FR 31647), Threatened**.**

2.2.2 Status of ESA-listed salmonid population(s) affected by the program.

Describe the status of the listed natural population (s) relative to "critical" and "viable" population thresholds.

Middle Columbia River Steelhead *(Oncorhynchus mykiss*) March 19, 1998; 64 FR 14508, Threatened.

Within the Middle Columbia River Steelhead ESU, hatchery steelhead stocks from outside the ESU are imported and released into the White Salmon (Skamania Hatchery winter and summer steelhead), Klickitat (Skamania Hatchery winter and summer steelhead) and Walla Walla (Lyons ferry), The BRT concluded that the Middle Columbia steelhead ESU is not presently in danger of extinction, but reached no conclusion regarding its likelihood of becoming endangered in the foreseeable future. Winter steelhead are reported within this ESU only in the Klickitat River and Fifteenmile Creek. Information on steelhead abundance, productivity and population growth trends is reported in NOAA 2005.

Summer and Winter Runs:
The existence of naturally spawning winter steelhead was confirmed in the early 1980s, and winter steelhead are presumed to be indigenous. Howell et al. (1985) recognized both summer and winter races of steelhead in the Klickitat Subbasin, with an adult winter steelhead migration period of January through May and a spawning period of March through June. To protect the winter run, current regulations prohibit sport fishing for steelhead in the Klickitat River from December through May and the treaty fishery is closed from January through March. Both seasons have been longer in previous years.

The most comprehensive set of steelhead spawner survey data was collected between 1996 and 2006. Redd counts over these years indicate an average escapement of 260 fish. This figure is undoubtedly an underestimate due to the inherent difficulty in conducting accurate counts during spring flow conditions. Mainstem spawning distribution is concentrated between RKm 8 and RKm 80.0, with occasional spawning above Castile Falls. Tributary spawning occurs in Swale, Wheeler, Summit, and White creeks and the upper Little Klickitat River.

Columbia Basin DPS Bull Trout *(Salvelinus confluentu*s) June 10, 1998 (63 FR 31647), Threatened.
The Fish and Wildlife Service issued a final rule listing the Columbia River and Klamath River populations of bull trout *(Salvelinus confluentu*s) as a threatened species under the Endangered Species Act on June 10, 1998 (63 FR 31647). The Columbia River Distinct Population Segment is threatened by habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, and past fisheries management practices such as the introduction of non-native species.

The Lower Columbia Recovery Unit Team identified two core areas (Lewis and Klickitat rivers) within the recovery unit. The Klickitat Core Area includes all tributaries downstream to the confluence with the Columbia River. Recent evidence indicates both resident and adfluvial bull trout are present in the Subbasin. Numerous confirmed and anecdotal reports of bull trout exist in the mainstem Klickitat River from the mouth up to the area below Castile Falls. Sizes reported are indicative of an adfluvial life history. Presence of resident populations has also been documented in the West Fork Klickitat River, Fish Lake Stream, Little Muddy Creek, Trappers Creek, Clearwater Creek, Two Lakes Stream, and an unnamed tributary to Fish Lake Stream (all within the West Fork Klickitat watershed).

The abundance of the stock in the Klickitat River is poorly known. There are insufficient data to make an assessment. However, it appears that there are very few bull trout in the lower- to mid-Klickitat drainage. Bull trout appear to be more abundant in the upper drainage where habitat conditions are more favorable.

Preliminary results of recent genetic analysis indicate that resident bull trout in the Klickitat Subbasin are genetically distinct from other Columbia tributary populations, but that fish in two West Fork Klickitat tributaries (Trappers and

Clearwater creeks) do not differ significantly from each other.

The impacts of hatchery salmon and steelhead in the main Klickitat River on bull trout are unknown. Generally, in drainages colonized by anadromous salmon and steelhead, char successfully co-exist by occupying a different ecological niche. However, negative interactions (predation) may occur when hatchery fish are released near char spawning and rearing areas.

2.2.3 Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed fish in the target area, and provide estimated annual levels of take.

No direct take of listed fish populations occurs for this program. Program risks are described below:

Broodstock Program

Broodstock Collection: To be performed at Wahkiacus, Lyle Falls, and Klickitat Hatchery. Risks to listed steelhead or bull trout from broodstock collection are expected to be minimal as neither species is present when coho adults return to hatchery facilities.

Genetic introgression: Coho are not believed to be native to the Klickitat watershed because Lyle Falls (RKm 3.5) was impassable to coho at the time the adults arrived in the late summer and early fall. This stock is of non-native origin and is sustained by hatchery production. Since 1988, Type N coho smolts from Washougal Hatchery and Klickitat Hatchery have been released. These releases have resulted in a small population of naturally spawning fish.

Rearing Program

Operation of Hatchery Facilities: Water rights are formalized through trust water rights from the Department of Ecology. Monitoring and measurement of water usage is reported in monthly NPDES reports. Intake structures were designed and constructed to specifications current at the time the Klickitat facility was constructed. The Mitchell Act Intake and Screening Assessment (2002) has identified design and alternatives needed to get existing structures including intake screens and velocity sweeps into compliance with NOAA fish-screening standards. From the assessment, WDFW has been requesting funding for future scoping, design, and construction work of a new intake system. All Subbasin facilities operate under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). WAG 13-5002. Monthly and annual reports on water quality sampling, use of chemicals, and compliance records for the Klickitat Hatchery facility are available from DOE.

Water diversion:

Wahkiacus Hatchery Acclimation Facility: This new facility will divert a maximum of 24 cfs from the mainstem Klickitat River (maximum occurs in May). The diversion will reduce river flow in 0.25 miles of the stream by about 1%.

Water Diversion Screening:

Wahkiacus Hatchery Acclimation Facility: The water diversion at this site will be screened according to NMFS criteria for fry; therefore injury or mortality to listed species is expected to be negligible.

Disease: Outbreaks in the hatchery may cause significant adult, egg, or juvenile mortality. Over the years, rearing densities, disease prevention, and fish health monitoring have greatly improved the health of the programs at Klickitat Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the population health. Indirect take from disease is unknown.

Release Program

Competition and Predation: According to the HSRG (2004) and Flagg et al. (2000), the potential for predation of wild salmonids by hatchery-reared smolts will depend on the size, number, and spatial distribution of both predators and prey, the functional and numerical responses of the predators, and the amount of time that predators and prey are in proximity. Busack et al. (2005) reviewed published rates of predation by juvenile hatchery salmonids on wild juvenile Chinook and found predation rates were generally low (<2% of natural population consumed). In contrast, data collected on hatchery coho predation rates on wild fall Chinook juveniles in the Lewis River were quite high (>11%) (Hawkins and Tipping 1999). The variability in study results is one reason the HSRG (2004) suggests that hatcheries monitor predation impacts resulting from hatchery releases.

In general, hatchery fish can consume fish that are 50% of their body size; however, studies reviewed by Busack et al. (2005) indicated that the range may extend from approximately 38% (steelhead) to 75% (coho). NOAA Fisheries and the USFWS, in a number of biological assessments and opinions, are of the opinion that juvenile salmonids can consume prey at ~33% of their body length (USFWS 1994; NMFS 1999). Predation by hatchery fish on wild fish can occur anywhere the two stocks exist in space and time. Therefore, predation may not only be a concern in the stream environment, but also in the estuary and marine environment.

The site-specific nature of predation and the limited number of empirical studies that have been conducted make it difficult to predict the predation effects of this specific hatchery release. The YN is unaware of any studies that have empirically estimated the predation risks to listed fish posed by the Klickitat

Hatchery programs. In the absence of site-specific empirical information, the identification of risk factors can be a useful tool for reviewing hatchery programs while monitoring and research programs are developed and implemented.

Risk Factors:

Date of Release: The release date can influence the likelihood that listed species are encountered. Coho will be released in early May, which is near the start of steelhead emergence from the gravel. Because coho smolts are unlikely to be use the shallow low velocity habitat preferred by steelhead fry, impacts due to predation and competition should be minor.

Fish Size at Release: Based on the 33% of body length predation assumption put forward by NMFS and USFWS, and a coho size of release range of 130-150 mm, hatchery coho may consume listed steelhead that range in size from 43-50 mm. During release period (May), the majority of steelhead juveniles present in the system are expected to be 1+ smolts that are generally larger than 80 mm. These fish are considered to be too large to be consumed by hatchery juvenile coho.

Release Location and Release Type: The likelihood of predation may also be affected by the location and the type of release. Other factors being equal, the risk of predation may increase with the length of time that fish co-mingle. In the freshwater environment, this is likely to be affected by distribution of the listed species in the watershed, the location of the release, and the speed at which fish released from the program migrate. Coho will be released volitionally from rearing sites located at RKm 27. Based on data collected in the Cowlitz River (Harza 1998), coho smolts are likely to migrate approximately 25 kilometers per day. At this migration rate, coho should take from 1 to 7 days to migrate out of the Subbasin. The small amount of time the hatchery fish are present in the Klickitat River should reduce possible competition and predation effects to listed fish species.

Residualism: To maximize smolting characteristics and minimize residualism, the YN Tribe adheres to a combination of acclimation, volitional release strategies, size, and time guidelines as developed at the Cle Elum Supplementation and Research Facility (CESRF) These same guidelines will apply to coho released in the Klickitat River. The following actions will be taken reduce residualism:

- Fish Condition factors, standard deviation and co-efficient of variation (CV) on lengths of fish will be measured throughout the rearing cycle and at release.

- Feeding rates and regimes throughout the rearing cycle will be programmed to satiation feeding to minimize size variations and re-programmed as needed to achieve goals for smolt size at time of release.

- o Releases will occur within the typical migration period for wild coho in the Columbia River Basin (May).

- o Fish will be released volitionally from acclimation ponds to ensure good smoltification and quick migration from the system. ATP-ase data will be collected to confirm the onset and pace of smoltification.

Migration Corridor/Ocean*:* The Columbia River hatchery production ceiling of approximately 197.4 million fish (1994 release levels) called for in the Proposed Recovery Plan for Snake River Salmon has been incorporated by NOAA-Fisheries into their recent hatchery biological opinions to address potential mainstem corridor and ocean effects, as well as other potential ecological effects from hatchery fish. Although hatchery releases occur throughout the year, approximately 80% occur from April to June. Columbia River mainstem out-migration occurs primarily from April through August (www.fpc.org). It is unknown to what extent listed fish are available both behaviorally and spatially on the migration corridor. Once in the main stem Columbia River, Witty et al. (1995) has concluded that predation by hatchery production on wild salmonids does not significantly impact naturally produced fish survival in the Columbia River migration corridor. In a study designed to define the migrational characteristics of Chinook salmon, coho salmon, and steelhead trout in the Columbia River estuary, Dawley et al. (1984) found the average migration rates for subyearling Chinook, yearling Chinook, and coho salmon and steelhead, were 22, 18, 17, and 35 RKm/d respectively. There appear to be no studies demonstrating that large numbers of Columbia system smolts emigrating to the ocean affect the survival rates of juveniles in the ocean. The lack of studies appears to be due, in part, to the dynamic nature of fish rearing conditions in the ocean and an inability to measure.

Monitoring:

Smolt Monitoring- Smolt traps above Castile Falls, near the Klickitat Hatchery and lower Klickitat River will be used to monitor hatchery fish migration timing and abundance.

Adult trapping at Lyle Falls, Castile Falls, and Klickitat River Hatchery will be monitored for impacts to listed adults.

These activities have the potential to harass, kill, or injured handled fish as evidenced by the data presented in the following table:

The number of juvenile steelhead handled and resultant mortality at the Lyle Falls rotary screw trap (2003-2006).

	Workups		Tallies		Grand Totals		
Year	Morts	Total Handled	Morts	Total Handled	Morts	Total Handled	% mortality
2003	8	764	64	515	72	1279	5.6%
2004	1	486	110	2054	111	2540	4.4%
2005	1	379	8	817	9	1196	0.8%
2006	0	81	0	35	0	116	0%
Totals					192	5131	3.7%

Research:

No research program is associated with the coho hatchery program.

Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

Data on the take of listed species are presented in the following table. It is anticipated that up to 50 steelhead adults may be handled at upstream trapping facilities. It must be noted that natural-origin steelhead will also be collected for the Klickitat River Hatchery Steelhead Program. As long as both hatchery programs are operational, impacts to adult steelhead will be shared.. If the steelhead program were to be discontinued, then the 50 adult take would apply only to the spring Chinook program.

Estimated listed salmonid take levels by hatchery activity.

	Steelhead
ESU/Population	Middle Columbia River Steelhead
Activity	Klickitat Hatchery Coho Program
Location of hatchery activity	Klickitat R. Hatchery
Dates of activity	Yearly
Hatchery Program Operator	WDFW

Type of Take	Annual Take of Listed Fish by life Stage (number of fish)			
	Egg/Fry	Juvenile /Smolt	Adult	Carcass
Observe or harass (a)				
Collect for transport (b)				
Capture, handle, and release (c)		5,000*	50*	
Capture, handle, tag/mark/tissue sample, and release (d)				
Removal, e.g. broodstock (e)				
Intentional lethal take (f)				
Unintentional lethal take (g)				
Other take (indirect, unintentional) (h)				

* Past juvenile trapping operations have captured ~5,000 steelhead parr and smolts.
** Although steelhead have not been taken during past hatchery practices, it is anticipated that adult steelhead will be collected and handled at the new collection facilities at Lyle Falls and Castile Falls. No mortality is expected from these operations.

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.

Any mortality or handling of listed steelhead that exceeds the values shown above will be communicated to Fish Program staff for additional guidance. The YN Senior Fisheries Biologist, along with the Hatchery Complex Manager, will determine an appropriate plan of action through consultation with NOAA. With the exception of unusual events that could not be forecasted, take limits will not be exceeded without prior approval from NOAA.

Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish.

Because few steelhead or bull trout are expected to be migrating when coho adults are being collected, broodstock collection activities impacts to either species should be minor to negligible.

Section 3: Relationship of Program to Other Management Objectives

3.1 Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. *Hood Canal Summer Chum Conservation Initiative*) or other regionally accepted policies (e.g. the *NPPC Annual Production Review* Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.

For ESU-wide hatchery plans, the plant of coho to the Klickitat River is consistent with:

- 1999 Biological Opinion on Artificial Propagation in the Columbia River Basin (NMFS 1999)
- Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995)
- The *U.S. v. Oregon* Columbia River Fish Management Plan
- Columbia River Basin Fish and Wildlife Program (http://www.nwcouncil.org/library/2000/2000-19/Default.htm)
- NPPC Annual Production Review Report
- Principles and Recommendations of the HSRG (HSRG 2004) Yakima/Klickitat Fisheries Project (YKFP or Project)
- Klickitat River Anadromous Fisheries Master Plan (2008 in draft).
- Draft Klickitat Subbasin Recovery Plan for Middle Columbia River Steelhead ESU. Klickitat River Steelhead Recovery Plan (NOAA-Portland 2007).Working Draft NOAA-Portland 2007

For statewide hatchery plan and policies, hatchery programs in the Columbia system adhere to a number of guidelines, policies, and permit requirements in order to operate. These constraints are designed to limit adverse effects on cultured fish, wild fish and the environment that might result from hatchery practices. Following is a list of guidelines, policies, and permit requirements that govern Columbia hatchery operations for the production of coho in the Klickitat River:

Genetic Manual and Guidelines for Pacific Salmon Hatcheries in Washington. These guidelines define practices that promote maintenance of genetic variability in propagated salmon. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).

Hatchery Reform: Principles and Recommendations of the Hatchery Scientific Review Group (HSRG): Provides guidance on hatchery operations and their impacts to native salmon populations. The program is using HSRG recommendations for broodstock management.

Stock Transfer Guidelines: This document provides guidance in determining allowable stocks for release for each hatchery. It is designed to foster development of locally adapted broodstock and to minimize changes in stock characteristics brought on by transfer of non-local salmonids (WDF 1991).

Spawning Guidelines: provides guidance on the mating and spawning protocols followed at WDFW hatcheries (Seidel 1983).

Fish Health Policy in the Columbia Basin: Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin. Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Fish Policy Chapter 5, IHOT 1995).

National Pollutant Discharge Elimination System Permit Requirements This permit sets forth allowable discharge criteria for hatchery effluent and defines acceptable practices for hatchery operations to ensure that the quality of receiving waters and ecosystems associated with those waters are not impaired.

3.2 List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

The program described in this HGMP is consistent with the following agreements and plans:

- The Columbia River Fish Management Plan
- Klickitat Master Plan
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- *U.S. v. Oregon* court decision
- Production Advisory Committee (PAC)
- Technical Advisory Committee (TAC)
- Integrated Hatchery Operations Team (IHOT) Operation Plan 1995 Volume III.
- Pacific Northwest Fish Health Protection Committee (PNFHPC)
- In-River Agreements: State, Federal, and Tribal representatives
- Northwest Power Planning Council Subbasin Plan
- Memorandum of Understanding Joint Operating Agreement for the Klickitat Hatchery (WDFW and YIN)

3.3 Relationship to harvest objectives.

The *U.S. v. Oregon* Columbia River Fish Management Plan recognized the importance of tribal harvest in the Klickitat River by mandating release of 3.85-million coho in the river annually since 1988. With these releases, sales of coho have provided a steady contribution to tribal commercial fall season fisheries.

The Klickitat River coho program provides fish for harvest in marine and freshwater areas. A summary of harvest by area is shown below (See Appendix B for yearly data).

Average Yearly Harvest Numbers For Klickitat River Origin Hatchery Coho (1987-2005)

Fishery Location	Number of Fish Caught
Marine	8,460
Lower Columbia River	2,465
Klickitat River	4,576

The reduction in program size from approximately 3.7 million to 1.0 million is likely to reduce harvest benefits over the short-term. It is anticipated that by producing higher quality smolts, and using acclimation techniques proven effective in the Yakima River, survival rates of released fish will increase to make up for this possible loss.

3.4 Relationship to habitat protection and recovery strategies.

For coho, natural production is not an objective because it was unlikely that coho spawned above Lyle Falls in the past.

Coho production and harvest objectives have been considered in the following documents.

Klickitat Sub basin Recovery Plan for the Mid Columbia ESU- This plan provides habitat strategies to be used to recover ESA-listed steelhead in the Klickitat Subbasin. The hatchery program has considered current and future habitat conditions in sizing program and defining release locations

Klickitat River Anadromous Fisheries Master Plan (2008 in draft): This document describes actions needed to protect and restore stream habitat in the Klickitat River as well as the basis for hatchery operations.

Yakama Nation Fisheries Program (YNFP):
The Lower Klickitat Riparian and In-Channel Habitat Enhancement Project is a BPA-funded watershed restoration project implemented by the Yakama Nation Fisheries Program (YNFP). The YNFP is working in coordination with WDFW, Natural Resources Conservation Service (NRCS), and the Central Klickitat Conservation District. The project was proposed under the Northwest Power Planning Council's Fish and Wildlife Program and funded by BPA in 1997. Initial project restoration projects were located within the Swale Creek and Little Klickitat River watersheds. Included in the project scope of work are in-stream structural modifications, re-vegetation of the riparian corridor, construction of sediment retention ponds to provide late-season flow to the creek and exclusion fencing to prevent channel degradation from livestock. A monitoring program has been initiated to document project success and guide future restoration activities. The second phase of the project will use EDT modeling output to guide and prioritization restoration activities.

Subbasin Planning and Salmon Recovery:
A regional sub-basin planning process is a broad-scale initiative that will provide building blocks of recovery plans for listed fish. The spring Chinook

hatchery program is designed to be consistent with the goals identified in this plan (NPPC 2004).

Limiting Factors Analysis:
A WRIA 30 (Klickitat Basin) habitat limiting factors report (LFA) has been completed by the Washington State Conservation Commission. This limiting habitat factors analysis was conducted pursuant to RCW 75.46 (Salmon Recovery). The purpose of this analysis was "to identify the limiting factors for salmonids" where limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon." It was intended that a locally based habitat project selection committee use the findings of this analysis to prioritize appropriate projects for funding under the state salmon recovery program. This analysis may also be used by local organizations and individuals interested in habitat restoration to identify such projects (Washington State Conservation Commission 1999). Habitat and hatchery actions will be coordinated as part of Subbasin planning.

The Strategic Plan For Salmon Recovery (HB 2496): Klickitat County functions as the lead entity for this plan which includes Klickitat major creeks, Big White Salmon and Little White Salmon. This document provides the prioritized actions addressing limiting factors from which the Salmon Recovery Funding Board projects are ranked for consistency and effectiveness.

3.5 Ecological interactions.

Salmonid and non-salmonid fishes or species that could negatively impact the program:

Klickitat coho smolts can be preyed upon through the entire migration corridor from the Subbasin to the mainstem Columbia River and estuary. Northern pikeminnows and introduced spiny rays along the Columbia mainstem sloughs can prey on coho smolts. Avian predators, including gulls, mergansers, cormorants, belted kingfishers, great blue herons, and night herons can also prey on coho smolts. Mammals that can take a heavy toll on migrating smolts and returning adults include: harbor seals, sea lions, river otters, and Orcas.

Salmonid and non-salmonid fishes or species that could be negatively impacted by the program:

Natural salmon and steelhead populations that co-exist in local tributary areas and the Columbia River mainstem corridor areas could be negatively impacted by program fish. Of primary concern are the ESA-listed endangered and threatened salmonids: including Snake River fall-run Chinook salmon ESU (threatened); Snake River spring/summer-run Chinook salmon ESU (threatened); Lower Columbia River Chinook salmon ESU (threatened); Upper Columbia River spring-run Chinook salmon ESU (endangered); Columbia River chum salmon ESU (threatened); Snake River sockeye salmon ESU (endangered); Upper Columbia River steelhead ESU (endangered); Snake

River Basin steelhead ESU (threatened); Lower Columbia River steelhead ESU (threatened); Middle Columbia River steelhead ESU (threatened); and the Columbia River distinct population segment of bull trout (threatened). Listed fish can be impacted through a complex web of short- and long-term processes and over multiple time periods which makes evaluation of this effect difficult. YN is unaware of studies directly evaluating adverse ecological effects to listed salmon.

Salmonid and non-salmonid fishes or other species that could positively impact the program.

Other wild and hatchery salmonids may provide nutrients to the Klickitat River upon their return as adults. These carcasses may increase stream productivity, which in turn may increase food abundance for coho.

Salmonid and non-salmonid fishes or species that could be positively impacted by the program.

Aquatic and terrestrial species that consume salmonids will benefit from the continued release of fish from this program. Common species that may benefit include northern pikeminnow, smallmouth and largemouth bass, gulls, mergansers, cormorants, belted kingfishers, great blue herons, night herons, harbor seals, sea lions, river otters, bea, and killer whales (Orcas). Additionally, salmon carcasses act as a source of fertilizer that can benefit plants that provide nutrients back to the stream.

Section 4. Water Source

4.1 Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile and natural limitations to production attributable to the water source.

A water right for the Wahkiacus Hatchery and Acclimation Facility will be obtained from the Washington DOE. Water for rearing will include a combination of shallow wells and non-consumptive river water.

This facility will use up to 24 cfs of river water from the Klickitat River. Water quality in the area is acceptable for spring and early summer acclimation. High turbidity during storm events may cause short-term problems in juvenile fish rearing and feeding.

4.2 Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

Hatchery water withdrawal	New water permits will be obtained from the DOE for the Wahkiacus Hatchery Facility and Acclimation Ponds. The maximum amount of river water to be diverted in any month will be 24 cfs, or ~ 1% of total stream flow. The water right will be for non-consumptive use. Monitoring and measurement of water usage is reported in monthly NPDES reports.
Intake/Screening Compliance	Intake structures at the WHAF facility will be designed and constructed to NMFS specifications.
Hatchery effluent discharges. (Clean Water Act)	All hatchery facilities will operate under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). WAG 13-5002. Monthly and annual reports on water quality sampling, use of chemicals at this facility, and compliance records will be available from DOE. Discharges from the cleaning treatment system will be monitored as follows: *Total Suspended Solids (TSS):* Collected 1 to 2 times per month on composite effluent, maximum effluent and influent samples.

	Settleable Solids (SS): Collected 1 to 2 times per week on effluent and influent samples. *In-hatchery Water Temperature* - Daily maximum and minimum readings.

Section 5. Facilities

5.1 Broodstock collection facilities (or methods).

Broodstock will be collected at Wahkiacus, Lyle Falls, or the Klickitat Hatchery. Fish will be collected randomly throughout the entire coho adult migration period.

5.2 Fish transportation equipment (description of pen, tank, truck, or container used).

1 million pre-smolts will be transported by truck from the Washougal Hatchery using protocols identified in Hager and Costello (1999). Fish transfers will be eliminated over time as a local broodstock source is created.

5.3 Broodstock holding and spawning facilities.

New broodstock holding and spawning facilities will be incorporated into the Wahkiacus Hatchery (See *draft* Klickitat River Anadromous Fisheries Master Plan for detailed description [Yakima Nation 2008])

5.4 Incubation facilities.

See Washougal River Type N coho HGMP. New facilities may be developed in the basin if data collected over the next 10 years indicate that survival rates for released fish are sufficient to meet harvest goals (See Klickitat River Anadromous Fisheries Master Plan [Yakama Nation 2008])

5.5 Rearing facilities.

Coho pre-smolts will be reared at acclimation facilities located at the new Wahkiacus facility.

Facility Description:

One large pond (225' long, 110' wide, and 4.0' deep), three medium ponds (180' long by 60' wide by 4.0' deep), and 4 small ponds (100' long, 34' wide, and 3.5' deep) will be constructed. The ponds will be formed from dirt on the site and will be lined with plastic. They will have overhead netting to reduce predator losses and to provide cover. Outlet structures will be equipped with dam boards to control water levels and screens that prevent fish escape.

5.6 Acclimation/release facilities.

See 5.5.

5.7 Describe operational difficulties or disasters that led to significant fish mortality.

This site does not yet exist; data are not available.

5.8 Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

Potential Hazard	Risk Aversion Measure
Equipment failure/Water loss	See below
Flooding/Water Loss	The facility is sited to minimize the risk of catastrophic fish loss from flooding and equipped with low water alarm probes in strategic locations to prevent fish mortality due to loss of water. Alarm systems will be monitored 24/7 with staff available on-station to respond to problems. Under 100-year flood conditions, pond berms may be overtopped. Fish could be washed out of the system during these events. Debris entering the ponds will need to be removed, ponds cleaned, and repaired.
Disease Transmission	USFWS fish health guidelines will be followed. USFWS fish health pathologist will conduct inspections monthly and problems are managed promptly to limit mortality and reduce possible disease transmission.

Section 6. Broodstock Origin and Identity

6.1 Source.

The new program will use local-origin coho adults returning to the Klickitat River.

6.2.1 History.

The Hatchery program began with local stocks and some imported Toutle "Early" stock coho in 1958-59. In 1985, late stock coho were introduced from the Cowlitz Salmon Hatchery. Since that time, in most years, production has been a composite of late run Washougal and Lewis River Type N Coho.

Broodstock Source	Origin	Year(s) Used	
		Begin	End
Cowlitz Hatchery Type N Coho	H	1985	
Washougal Hatchery Type N Coho	H	1999	Present
Lewis River Hatchery Type N Coho	H	1995	2001
Kalama River Hatchery Type N Coho	H	1999	
Elochoman Hatchery Type N Coho	H	1999	

6.2.2 Annual size.

Approximately 750 adults will be needed for broodstock. The number of adults collected will depend on female fecundity and pre-spawn mortality rates.

6.2.3 Past and proposed level of natural fish in the broodstock.

None proposed. The goal is to avoid establishing a wild population of coho in the Subbasin.

6.2.4 Genetic or ecological differences.

No indigenous stock of coho exists in the Klickitat River.

6.2.5 Reasons for choosing.

Local broodstock are expected to possess the life-history traits and behavior necessary to survive in the Klickitat River Subbasin.

6.3 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices.

Adult trapping is monitored daily for incidental capture of listed steelhead and bull trout; ESA-listed fish are identified and quickly returned to the river.

The new Lyle Falls fish ladder and trapping facility will be designed to meet NMFS fish handling criteria. Following these guidelines should reduce impacts to listed fish.

No genetic effects are expected because as coho are not native to the Subbasin.

Section 7. Broodstock Collection

7.1 Life-history stage to be collected (adults, eggs, or juveniles).

Adults

7.2 Collection or sampling design

Adults will be collected randomly throughout the entire run. Initially, adults will be collected at the Washougal Hatchery, then at Wahkiacus, Lyle Falls and (possibly) the Klickitat Hatchery as the program is converted to local broodstock.

7.3 Identity.

The long-term goal is to maintain a run of hatchery adults returning to the Klickitat River.

7.4 Proposed number to be collected:

750 adults

7.5 Disposition of hatchery-origin fish collected in surplus of broodstock needs.

Surplus hatchery fish will be given to tribal members or used as part of a stream nutrient enhancement program for the Subbasin.

7.6 Fish transportation and holding methods.

The transport protocols defined in Hager and Costello (1999) will be followed. Transport time from trapping facilities to the adult holding ponds will be less than 1 hour.

In the future, adult coho will be held on river water at the Wahkiacus Hatchery. Adults will be injected with Erythromycin-200 at a dosage of 20-30 mg/kg of body weight upon capture and may receive additional treatments during holding depending on disease presence.

7.7 Describe fish health maintenance and sanitation procedures applied.

Transported adults will be injected with Erythromycin-200 at a dosage of 20-30 mg/kg of body weight upon capture (Hager and Costello 1999).

7.8 Disposition of carcasses.

Carcasses will either be frozen and used for nutrient supplementation activities or buried in an upland landfill.

7.9 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program.

No genetic effects are expected to natural coho stocks because coho are not native to the Subbasin. Ecological risks to listed steelhead and bull trout are expected to be minimal because these species are generally not present at collection facilities during the adult coho migration period. Until the Wahkiacus facility is constructed, it is not known whether adult steelhead or bull trout will be impacted by WHAF operations.

Section 8. Mating

8.1 Selection method.

Cohorts will be taken from the entire run cycle. Mating will be done randomly with the males and females available on a given day.

8.2 Males.

Males will be utilized at a 1:1 spawning ratio whenever possible. No mini-jacks will be used as broodstock for the program.

8.3 Fertilization.

Eggs will be mixed with milt and water hardened with iodophor at a 1:600 concentration.

8.4 Cryo-preserved gametes.

Not used.

8.5 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

See Washougal or Lewis River Type N coho HGMP for current risks.

As coho are not listed in the Klickitat River, no genetic or ecological risks are expected from the future program.

Section 9. Incubation and Rearing.

9.1.1 Number of eggs taken and survival rates to eye-up and/or ponding.

Currently, eggs for this program eggs are taken at the Washougal Hatchery (see Washougal River Type N coho HGMP).

Future program will collect eggs from adults returning to the Subbasin. The number of eggs collected will be sufficient to produce 1.0 million smolts. Actual egg-take will be based on resulting survival rates for adult holding, collection, fecundity, egg transport, incubation, and rearing.

9.1.2 Cause for, and disposition of surplus egg takes.

For the Wahkiacus Hatchery, surplus eggs may result from unexpected variability in female fecundity or pre-spawn survival rates. Surplus eggs from HOR-origin fish will be destroyed and buried in the upland landfill

9.1.3 Loading densities applied during incubation.

See Washougal Type N Coho HGMP for initial program.

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin.

9.1.4 Incubation conditions.

See Washougal Type N Coho HGMP for initial program.

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin. These are expected to be similar to those used at the Washougal River Hatchery.

9.1.5 Ponding.

See Washougal Type N Coho HGMP for initial program.

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin.

9.1.6 Fish health maintenance and monitoring.

See Washougal Type N Coho HGMP.

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin.

9.1.7 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation.

See Washougal Type N Coho HGMP

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin.

9.2.1 Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years (1990-2001), or for years dependable data are available.

See Washougal Type N Coho HGMP

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin.

9.2.2 Density and loading criteria (goals and actual levels).

See Washougal Type N Coho HGMP

Will be developed for the Wahkiacus Hatchery if a decision is made to move forward with conducting incubation activities within the Subbasin.

9.2.3 Fish rearing conditions.

Fish will be transferred from Washougal Hatchery to the Wahkiacus Hatchery in March and reared on primarily river water for approximately 8 weeks. The fish will then be released volitionally from the ponds. Pond water temperatures will mimic river temperatures, which vary seasonally.

Half of the ponds are expected to be vacuumed each week, and all ponds just prior to fish release. Wastes will be sent to a settling pond. The ponds have been sized to easily hold pond effluent and cleaning wastes. The volume of effluent handled will be approximately 62,000 gallons per cleaning.

Fish will be fed to satiation daily and checked for signs of disease as well as behavior indicative of smoltification. ATP-ase samples will be collected from a random sample of fish starting in April each year.

9.2.4 Indicate biweekly or monthly fish growth information (average program performance), including length, weight, and condition factor data collected during rearing, if available.

Rearing Period	Length (mm)	Weight (fpp)	Condition Factor	Growth Rate
09.06	92.7	45	1.261	4866
10.06	99	37	1.235	8144
11.06	104	33.1	1.197	4078
12.06	105	32.3	1.215	509
01.07	111	28	1.203	4599

9.2.5 Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available.

Rearing Period	Length (mm)	Weight (fpp)	Condition Factor	Growth Rate
09.06	92.7	45	1.261	4866
10.06	99	37	1.235	8144
11.06	104	33.1	1.197	4078
12.06	105	32.3	1.215	509
01.07	111	28	1.203	4599

9.2.6 Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Rearing Period	Food Type	Application Schedule (feedings/day)	Feeding Rate Range (%B.W./day)	Lbs. Fed Per gpm of Inflow	Food Conversion During Period
1. 3/18/06-5/1/06	Ewos Micro #1	7	1.5	0.02	0.56
2. 5/1/06-5/16/06	Ewos Micro #2	5	1.9	0.03	0.56
3. 5/16/06-7/17/06	Ewos Pacific 1.2 mm	2	1.7	0.05	0.69
4. 7/17/06-2/5/06	Ewos Vita 1.5 mm	1	1.00	0.06	0.91

9.2.7 Fish health monitoring, disease treatment, and sanitation procedures.

Fish Health Monitoring	A fish health specialist inspects fish monthly and checks both healthy and if present symptomatic fish. Based on visual detection of pathological signs, age of fish and the history of the facility, the pathologist determines the appropriate tests. External signs such as lesions, discolorations, and fungal growths will lead to internal examinations of skin, gills and organs. Kidney and spleen are checked for bacterial kidney disease (BKD). Blood is checked for signs of anemia or other pathogens. Additional tests for virus or parasites are done if warranted.
Disease Treatment	Appropriate therapeutic treatment will be prescribed to control and prevent further outbreaks. Mortality is collected and disposed of at a landfill. Fish health and or treatment reports are kept on file.
Sanitation	All eggs brought to the facility are surface-disinfected with iodophor (as per disease policy). All equipment (nets, tanks, boots, etc.) is disinfected with iodophor between different fish/egg lots. Different fish/egg lots are physically isolated from each other by separate ponds or incubation units. The intent of these activities is to prevent the horizontal spread of pathogens by splashing water. Tank trucks are disinfected between the hauling of adult and juvenile fish. Footbaths containing disinfectant are strategically located on the hatchery grounds to prevent spread of pathogens.

9.2.8 Smolt development indices (e.g. gill ATPase activity), if applicable.

ATPase data will be collected to determine fish condition and release dates at the new Wahkiacus Hatchery.

9.2.9 Indicate the use of "natural" rearing methods as applied in the program.

Cover and substrate will be incorporated into the acclimation ponds.

9.2.10 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation.

Listed fish are not under propagation.

Section 10. Release

10.1 Proposed fish release levels.

Age Class	Max. No.	Size (fpp)	Release Date	Location			
				Stream	Release Point (RKm)	Major Water-shed	Eco-province
Yearling	1,000,000	15	May	Klickitat River	27	Klickitat	Columbia Gorge

10.2 Specific location(s) of proposed release(s).

Fish are to be released from a new acclimation site located at RKm 27 (Wahkiacus Hatchery).

10.3 Actual numbers and sizes of fish released by age class through the program.

New program: a total of 1.0 million coho will be released at 15 fpp.

10.4 Actual dates of release and description of release protocols.

Fish will be allowed to migrate volitionally from the acclimation sites starting in May. Fish that do not leave the ponds volitionally will be collected, destroyed, and buried in upland landfill area.

10.5 Fish transportation procedures, if applicable.

Fish will not be transported to release sites once the program has been converted to local broodstock and incubation facilities constructed in the basin. Before these two actions occur, fish will be transported following protocols identified in Hager and Costello (1999).

10.6 Acclimation procedures (*methods applied and length of time*).

Coho for this program will be acclimated for 8 weeks prior to the target release date.

10.7 Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.

10% (100,000) smolts will be CWT and adipose fin-clipped. The remaining 900,000 will be adipose clipped only. In Phase 2 of the program approximately 500,000 will be adipose fin-clipped, 100,000 ad+CWT, and the remainder unmarked. This action is designed to increase returns for locally adapted broodstock.

10.8 Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

Few surplus juvenile fish are expected as they will be counted prior to transfer from the Washougal Hatchery.

Initial operations at Wahkiacus Hatchery may result in surplus juveniles until staff becomes familiar with the operation of this facility. If surplus fish are produced, NMFS and other agencies will be informed and asked for a decision as to whether the fish should be released or destroyed.

10.9 Fish health certification procedures applied pre-release.

Prior to release from Wahkiacus Hatchery, fish population health and condition will be established by the USFWS Fish Health Pathologist. This is commonly done 1-3 weeks pre-transfer and up to 6 weeks on systems with pathogen-free water and little or no history of disease. Prior to this examination, whenever abnormal behavior or mortality is observed, staff will contact the USFWS Fish Health Pathologist. The Pathologist will examine affected fish and will recommend appropriate treatment. Reporting and control of selected fish pathogens are done in accordance with the Co-managers' Fish Disease Control Policy and IHOT guidelines.

10.10 Emergency release procedures in response to flooding or water system failure.

Emergency procedures and disposition of fish will adhere to the protocols and procedures set forth in approved operation plans. If the program is threatened by ecological events or mechanical failure, the Hatchery manager will inform regional management of the situation. Based on a determination of a partial or complete emergency release of program fish, if an on-station emergency release is authorized, personnel will pull screens and sumps and fish will be force- released into the Klickitat River.

10.11 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases.

- Smolts will be released volitionally from the Wahkiacus Hatchery (RKm 27). This release site is lower in the Subbasin than past release sites under this program. This action should reduce competition with and predation on listed fish species.
- Smolts plants have averaged 16.5 fpp (132 mm fl), a size which should reduce predation impacts on juvenile (fry and parr) steelhead.

Because Klickitat River coho are not listed (nor native to the Subbasin) the hatchery program will have no genetic effects on wild coho.

Section 11. Monitoring and Evaluation of Performance Indicators

11.1.1 Describe plans and methods proposed to collect data necessary to respond to each " Performance Indicator" identified for the program.

Harvest Contribution: Coho contribution to harvest will be estimated for each brood year by sampling ocean and freshwater fisheries for tagged fish. YN staff will sample tribal and sport fisheries in the Columbia River and Klickitat River Subbasin. WDFW and other fisheries agencies will monitor and record harvest rates in the ocean.

Smolt-to-Adult Survival (SAR): The data collected for harvest contribution will be combined with information gathered during spawning and carcass surveys to estimate SAR for coho. Spawning surveys will be conducted weekly throughout the spawning season.

Adult Straying: The Regional Mark Information System (RMIS) will be queried to determine the number of tagged Klickitat origin coho recovered at hatcheries and streams located outside of the Klickitat River basin. These data will be used to determine if the 5% stray rate criterion is being achieved.

Fish Health: The USFWS Fish Pathologist will monitor fish health at all facilities following standard reporting protocols and implement corrective measures as needed.

11.1.2 Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

Funding requested under the Klickitat River Anadromous Fisheries Master Plan is expected to be sufficient to implement M&E activities (Yakama Nation 2008).

11.2 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to <u>listed</u> fish resulting from monitoring and evaluation activities.

Spawning and carcass surveys will performed weekly to minimize interactions with adult and juvenile listed steelhead inhabiting basin streams. Surveying sport and tribal fishers will have no impact to listed species.

Section 12. Research

12.1 Objective or purpose.

No research is conducted for this program.

12.2 Cooperating and funding agencies.

12.3 Principle investigator or project supervisor and staff.

12.4 Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2.

12.5 Techniques: include capture methods, drugs, samples collected, tags applied.

12.6 Dates or time periods in which research activity occurs.

12.7 Care and maintenance of live fish or eggs, holding duration, transport methods.

12.8 Expected type and effects of take and potential for injury or mortality.

12.9 Level of take of listed fish: number of range or fish handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached “take table” (Table 1).

12.10 Alternative methods to achieve project objects.

12.11 List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

12.12 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury or mortality to listed fish as a result of the proposed research activities.

Section 13. Attachments and Citations

13.1 Attachments and Citations

Busack, C., K. Currens, T. Pearsons, and L. Mobrand. 2005. "Tools for Evaluating Ecological and Genetic Risks in Hatchery Programs", 2004 Final Report, Project No. 200305800, 91 electronic pages, (BPA Report DOE/BP-00016399-1).

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NOAA 2005. Updated Status of Federally Listed ESU's of West Coast Salmon and Steelhead. NOAA Technical Memorandum NMFS-NWFSC-66.

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NPPC 2004. Klickitat Subbasin Plan. Prepared for the Northwest Power and Conservation Council. Prepared by the Yakama Nation, Klickitat County, and Washington Department of Fish and Wildlife.

Seidel, Paul. 1983. Spawning Guidelines for Washington Department of Fish and Wildlife Hatcheries. Washington Department of Fish and Wildlife. Olympia, Wa.

USFWS (U.S. Fish and Wildlife Service). 1994. Biological assessment for operation of U.S. Fush and Wildlife Service operated or funded hatcheries in the Columbia River Basin in 1995-1998. Submitted to National Marine Fisheries Service (NMFS) under cover letter, dated August 2, 1994, from William F. Shake, Acting USFWS Regional Director, to Brian Brown, NMFS.

United States Fish and Wildlife Service 1998. Biological Opinion for the Effects to Bull Trout from Continued Implementation of Land and Resource Management Plans and Resource Management Plans as Amended by the Interim Strategy for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana, and Portions of Nevada (INFISH) and the Interim Strategy for Managing Anadromous Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). Region 1, Portland, Oregon.

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Yakama Nation 2008. Klickitat River Anadromous Fisheries Master Plan, Yakima/Klickitat Fisheries Program. Toppenish, WA.

Section 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

14.1 Certification Language and Signature of Responsible Party

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by______________________________ Date:_____________

Section 15

ADDENDUM A. PROGRAM EFFECTS ON OTHER (AQUATIC OR TERRESTRIAL) ESA-LISTED POPULATIONS

15.1) List all ESA permits or authorizations for USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species associated with the hatchery program.

No permits in place for this new program. They will be developed through consultation with appropriate agencies as facilities and programs are developed.

15.2) Describe USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species and habitat that may be affected by hatchery program.

Hatchery operations may impact federally listed Klickitat River bull trout (*Salvelinus confluentus*). Bull trout are listed as Threatened by the USFWS. The USFWS has designated the West Fork Klickitat River and Klickitat River reaches adjacent to the Yakama Indian Reservation as Critical Habitat (Federal Register 2005). Stream habitat in the Klickitat River Subbasin has been impacted by human activities associated with agriculture, logging, recreation, and urban development.

Hatchery facilities are located both within and near the Klickitat River. Water for rearing anadromous fish at the Klickitat River hatchery is diverted from the river. New juvenile acclimation sites are being developed at the Wahkiacus Hatchery (RKm 27). Construction of these facilities will disturb upland and riparian habitat near the stream channel. A diversion structure will also be built at this facility to provide water for acclimating hatchery smolts.

Other listed or candidate species that may be impacted by the construction and operation of the Wahkiacus Hatchery and Acclimation Facility Creek include:

Oregon Spotted Frog (*Rana pretiosa*)	Candidate
Bald Eagle (*Haliaeetus leucocephalus)*	Threatened
Northern Spotted Owl (*Strix occidentalis)*	Threatened

The possible impacts of facilities construction and operation may have on these species has not been quantified.

15.3) <u>Analyze effects.</u>

<u>Bull Trout</u>

Possible hatchery operational effects to listed bull trout in the Klickitat River are described below. The effects are expected to continue while the hatchery program is in place.

Water diversion: Water is diverted from the Klickitat River to operate the Wahkiacus Hatchery and Acclimation Facility. This action may result in a slight decrease in the amount (0.25 miles) and quality of stream habitat affected by stream de-watering. The habitat loss may result in a decrease in bull trout abundance. However, because bull trout are primarily found in the West Fork Klickitat River and tributaries higher in the Subbasin than the hatchery location, impacts to bull trout are expected to be minor.

Diversion Screens: The Wahkiacus Hatchery and Acclimation Facility water intakes will be screened to meet NMFS criteria for fry. Impacts to juvenile bull trout are expected to be negligible.

Waste and Pollutants: The facility will under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). Water meeting these standards is not expected to have adverse impacts on bull trout.

Disease: Outbreaks in the hatchery may cause significant adult, egg, or juvenile mortality. Over the years, rearing densities, disease prevention and fish health monitoring have greatly improved the health of the programs at Klickitat Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1994) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the populations' health. The level of <u>indirect take of bull trout from disease is unknown.</u>

Broodstock Collection: Broodstock will be collected at Wahkiacus Hatchery. Although few, if any, bull trout are likely to be captured at this facility, fish entering the facility could be injured by the equipment used to capture and process returning broodstock.

Acclimation Facilities: New acclimation facilities are to be constructed on the mainstem Klickitat River at RKm 27 (Wahkiacus Hatchery Acclimation Facility). Migratory adult and juvenile bull trout may be affected by facility operations.

Release of Juveniles: The program will release 1,000,000 coho into the Klickitat River each year. These fish may compete with and prey on juvenile bull trout. Smolt length at release will range from 130 to 150 mm. If it assumed that coho can consume fish that are up to 33% of their body length, there is the possibility that bull trout less than 46 mm may be susceptible to predation. However, because coho will not be released in the primary bull trout stream (West Fork Klickitat River), it is unlikely that the hatchery smolts will prey on, or compete with, listed bull trout.

Food: The carcasses of naturally spawning coho adults returning to the Subbasin may increase stream productivity through the addition of ocean-derived nutrients. Increased productivity may result in an increase in food availability to both juvenile and adult bull trout. Offspring of naturally spawning coho may also provide a food source for bull trout.

Monitoring and Evaluation: Smolt trapping may be used to determine that hatchery coho juveniles migrate quickly through the system after release. Some bull trout may be captured and handled at the trapping facilities.

Oregon Spotted Frog

Neither hatchery operations nor proposed new facilities are likely to impact this species. The only known population of Oregon Spotted Frog in the Klickitat River Subbasin is located in the Conboy Lake National Wildlife Refuge (NWR) managed by USFWS (NPPC 2004). The refuge is located approximately 10 miles east of Trout Lake and 7 miles southwest of Glenwood in the Glenwood Valley/Camas Prairie area.

Bald Eagle

Bald eagles can be found throughout the year in the Klickitat River Subbasin. Because this species feeds on salmon, increased hatchery production should result in an increase in food for this species as a result of more adult fish returning to the basin.

Northern Spotted Owl

No facilities will be located in, nor activities conducted in, areas inhabited by the Northern Spotted Owl or in suitable owl habitat.

15.4 Actions taken to minimize potential effects.

Bull trout

Diversion Screens: All intake screens will be built or updated to meet NMFS screen criteria for fry.

Waste and Pollutants: All terms and conditions associated with the NPDES Permit will be implemented and followed.

Broodstock Collection: Broodstock collection facilities will be designed to meet USFWS and NMFS criteria.

Acclimation Facilities: These facilities will be sited to reduce impacts to riparian and stream habitats. The YN will coordinate the location and construction of this facility with USFWS staff to minimize or avoid impacts to all listed species.

Monitoring and Evaluation: Bull trout collected during juvenile trapping operations will be returned unharmed to the stream.

Oregon Spotted Frog

Prior to constructing new facilities, the stream and riparian area near proposed sites will be surveyed for the presence of the Oregon Spotted Frog. If these frogs are found, the YN will coordinate with USFWS staff to develop mitigation and protection measures.

Bald Eagle

New facilities will not be located near bald eagle nests.

Northern Spotted Owl

The Wahkiacus Hatchery will not be located in Northern Spotted Owl habitat and, therefore, no adverse impacts are expected.

15.5 References

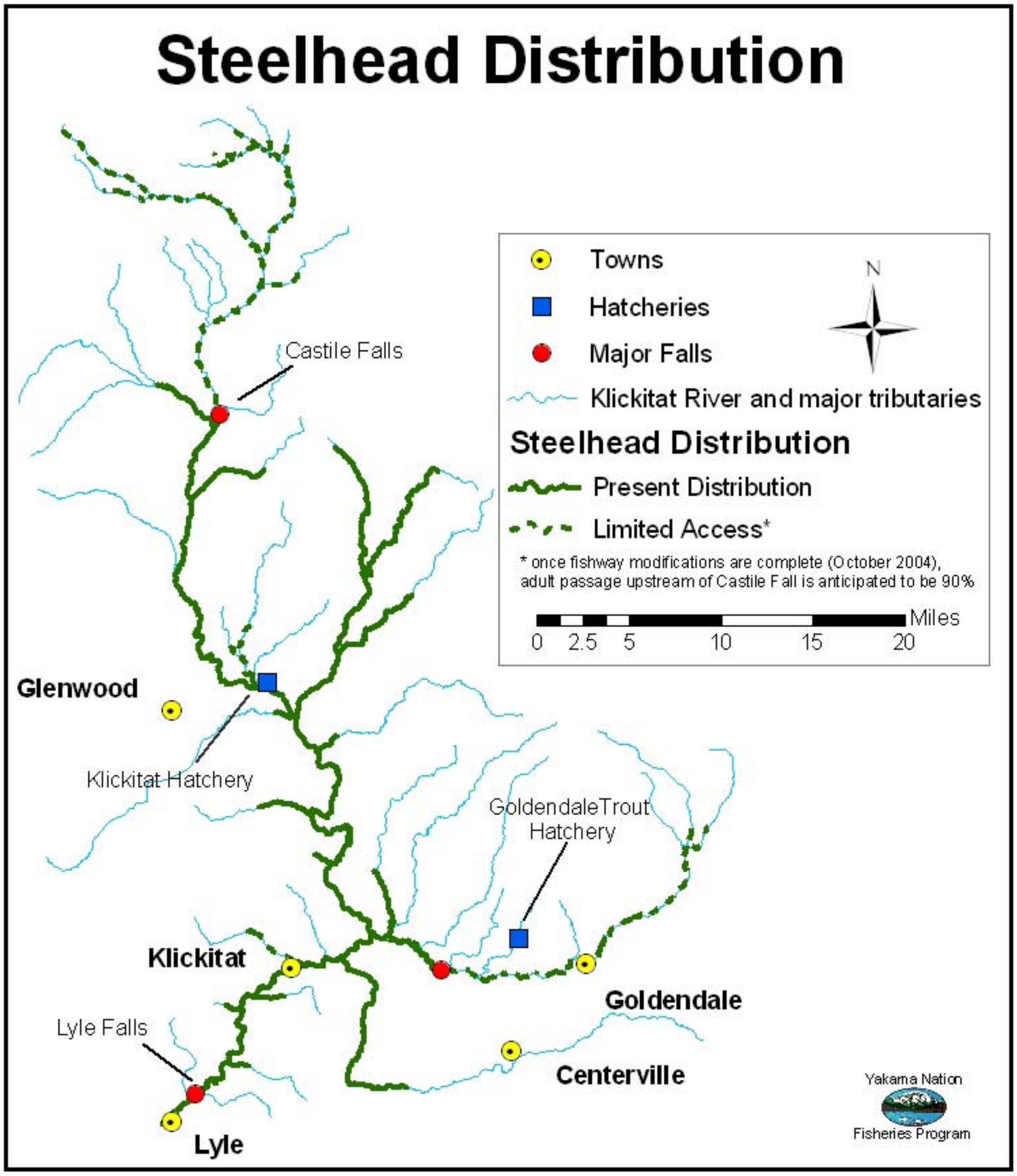
IHOT (Integrated Hatchery Operations Team). 1995. Operation plans for anadromous fish production facilities in the Columbia River basin. Volume III-Washington. Annual Report 1995. Bonneville Power Administration, Portland Or. Project Number 92-043. 536 pp.

NPPC 2004. Klickitat Subbasin Plan. Prepared for the Northwest Power and Conservation Council. Prepared by the Yakama Nation, Klickitat County, and Washington Department of Fish and Wildlife.

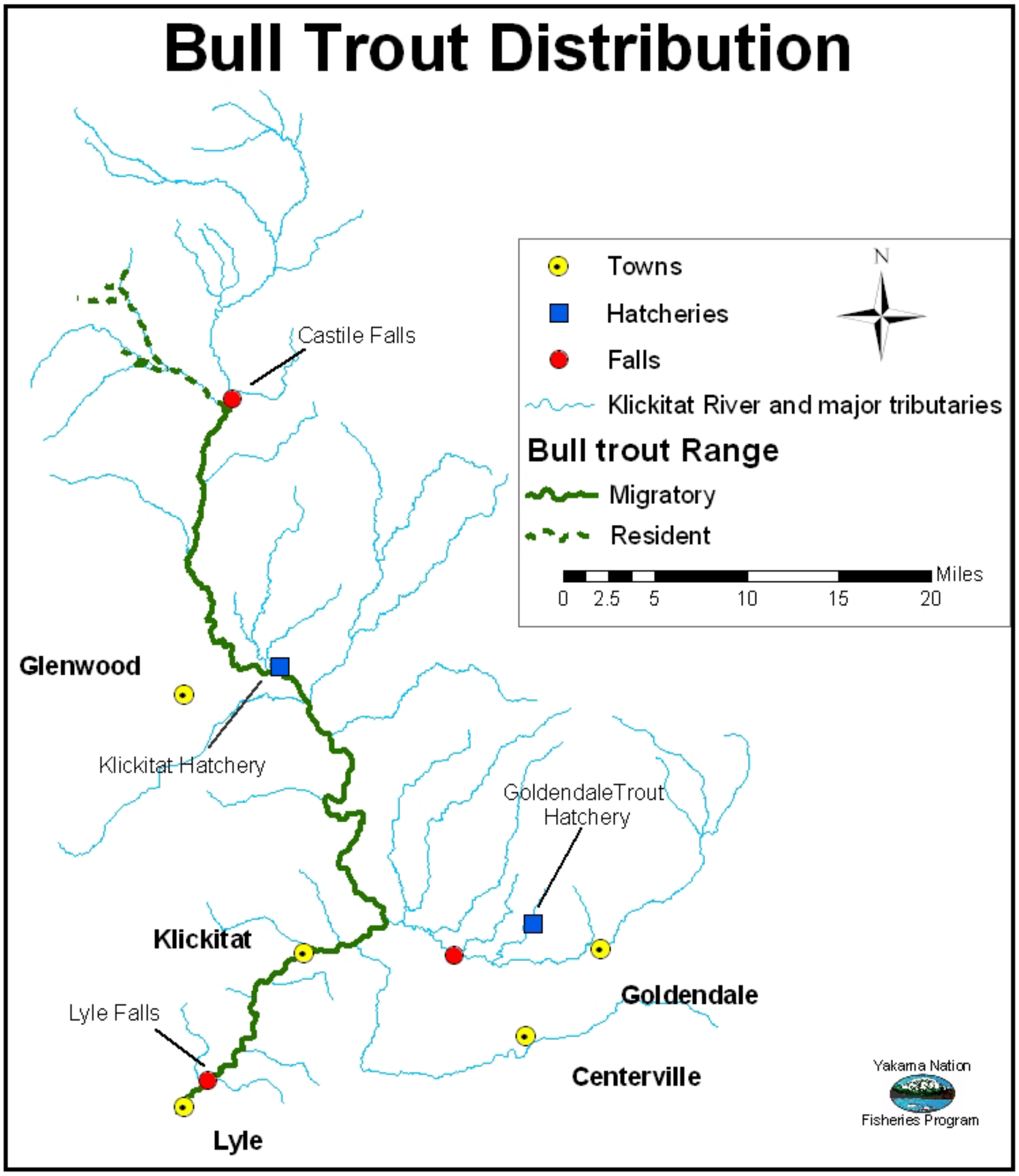
Yakama Nation 2008. *Draft* Klickitat River Anadromous Fisheries Master Plan, Yakima/Klickitat Fisheries Program. Toppenish,WA.

Appendix A- Steelhead and Bull Trout Distribution

Steelhead Distribution



Bull Trout


Bull Trout Distribution
Towns
Hatcheries
Falls
Klickitat River and major tributaries
Bull trout Range
Migratory
Resident
N
Miles
0 2.5 5 10 15 20
Castile Falls
Glenwood
Klickitat Hatchery
GoldendaleTrout Hatchery
Klickitat
Lyle Falls
Goldendale
Centerville
Lyle
Yakama Nation
Fisheries Program

Appendix B- Coho Harvest

Year	Klickitat River[1] Run	Klickitat River[1] Harvest	Klickitat River[1] Escape[2]	L. Col. R. Harvest[3]	Marine[4] Harvest	Total Harvest
1987	316	256	60	178	630	1,064
1988	12,386	9,619	2,767	8,666	20,292	38,577
1989	8,857	7,185	1,672	5,552		12,737
1990	3,055	2,478	577	1,131		3,609
1991	9,702	7,870	1,832	7,021	15,630	30,521
1992	534	433	101	232	1,505	2,170
1993	549	446	104	268	1,235	1,949
1994	3,882	3,149	733	1,451		4,600
1995	2,012	1,632	380	631		2,263
1996	896	698	198	231	3,254	4,183
1997	1,470	1,010	460	402	4,451	5,863
1998	3,379	2,846	533	546	5,578	8,970
1999	3,930	3,435	495	1,176	2,986	7,598
2000	5,808	4,871	938	1,855	3,211	9,937
2001	14,078	10,450	3,628	4,896	9,058	24,404
2002	9,901	8,701	1,200	3,340	7,220	19,262
2003	8,640	8,360	280	3,944	18,574	30,878
2004	5,959	5,817	143	1,816	13,695	21,328
2005	8,276	7,678	598	2,403	19,576	29,657
Avg[5]:	5,454	4,576	879	2,465	8,460	15,757

1. YN and WDFW database estimates.
2. Derived from redd count data assuming 2.5 fish per redd. For years when redd counts were unavailable, assumes average escapement-to-total-harvest ratio from years when redd counts were available. These data are likely underestimates, as water conditions often preclude accurate redd count estimates.
3. Derived from *U.S. v. Oregon* Technical Advisory Committee reports.
4. Derived from Regional Mark Information System (RMIS) recovery year data for marine and freshwater coded-wire tag (CWT) recoveries of coho released in the Klickitat River.
5. Klickitat River data are 1987-2005 averages. Averages for all other data are also for the period 1987-2005 and are exclusive of years when available CWT recovery data preclude an accurate estimate of marine harvest.

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Klickitat Fall Chinook

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HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Final DRAFT

Hatchery Program	Klickitat Fall Chinook
Species or Hatchery Stock	Chinook Salmon (*Oncorhynchus tshawytscha*)
Agency/Operator	Yakama Nation
Watershed and Region	Klickitat Subbasin/Columbia Gorge Province
Date Submitted	February 2008
Date Last Updated	February 2008

Section 1: General Program Description

1.1 Name of hatchery or program.

Klickitat URB Fall Chinook

1.2 Species and population (or stock) under propagation, and ESA status.

Upriver Bright Fall Chinook Salmon (*Oncorhynchus tshawytscha*)

ESA Status: Not listed and not a candidate for listing

1.3 Responsible organization and individuals.

Name (and title):	Jason Rau (Complex Manager)
	Bill Sharp (YKFP Klickitat Coordinator)
Agency or Tribe:	Yakama Nation
Address:	PO Box 151 Toppenish WA 98948
Telephone:	(509) 865-5121
Fax:	(509) 865-6293
Email:	jayrau@ykfp.org sharp@yakama.com

Other agencies, Tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program.

Co-operators	**Role**
Washington Dept. Fish & Wildlife (WDFW)	Fish Hatchery Specialist 1
United States Fish and Wildlife Service (USFWS)	Health Technician and Pathologist

1.4 Funding source, staffing level, and annual hatchery program operational costs.

Funding Sources
Currently Mitchell Act. Other funding sources may include John Day Mitigation or BPA

Operational Information	Number
Full time equivalent staff	1 FTE, 4-5 seasonal
Annual operating cost (dollars)	$275,000 (NPCC Step-1 estimate)

1.5 Location(s) of hatchery and associated facilities.

Broodstock source	Klickitat River Fall Chinook
Broodstock collection location (stream, RKm, subbasin)	Lyle Falls (Klicktat River RKm 3.5), Klickitat River Hatchery (Rkm 68), Wahkiacus (Rkm 27)
Adult holding location (stream, RKm, subbasin)	Klickitat River Hatchery (Rkm 68), Wahkiacus (Rkm 27)
Spawning location (stream, RKm, subbasin)	Klickitat River Hatchery (Rkm 68), Wahkiacus (Rkm 27)
Incubation location (facility name, stream, RKm, subbasin)	Klickitat River Hatchery (Rkm 68), Wahkiacus (Rkm 27)
Rearing location (facility name, stream, RKm, subbasin)	Klickitat River Hatchery/RKm 68. and Wahkiacus Hatchery (RKm 27)

1.6 Type of program.

Segregated Harvest

1.7 Purpose (Goal) of program.

The goal is to develop a locally adapted broodstock that achieves harvest objectives for terminal tribal and sport fisheries in the Klickitat River. Converting to the use of locally adapted broodstock is expected to increase survival rates for released fish, reducing the level of out-of-basin broodstock used in the program.

1.8 Justification for the program.

The program will be operated to provide fish for tribal and sport harvest while minimizing adverse affects on listed fish (steelhead and bull trout). Klickitat River fisheries were agreed to in US V Oregon and to mitigate for operation of the FCRPS, specifically John Day dam.

1.9 List of program "Performance Standards".

See section 1.10 below.

1.10 List of program "Performance Indicators", designated by "benefits" and "risks".

1.10.1 Benefits:

Benefits		
Performance Standard	**Performance Indicator**	**Monitoring & Evaluation**
Provide Fish to Meet Columbia River fish Mgt. Plan *(US v Oregon)*, production and harvest objectives.	Contribute to a meaningful harvest for sport, tribal and commercial fisheries. Objective is to provide 18,000 adult fish for harvest.	Contribution to fisheries will be estimated for each brood year released. Work with co-managers to manage adult fish returning in excess of broodstock needs
Smolt-to-adult survival (SAR)	SAR Value of 1%	SAR will be determined by counting tagged fish recovered at traps, broodstock collection facilities, sport and tribal fisheries and on the spawning grounds.
Straying of Klickitat River origin fish to other subbasins	Stray rate of less than 5%	Regional M&E efforts will be used to track the number and capture location of Klickitat River origin fish
Use of local origin fall Chinook for broodstcok	Broodstock consistes of 95% Klickitat origin fall Chinook.	Real-time DNA samples will be collected from all Chinook captured for this program.
Maintain outreach to enhance public understanding, participation and support of YN hatchery programs	Provide information about agency programs to internal and external audiences. For example, local schools and special interest groups tour the facility to better understand hatchery operations. Off- station efforts may include festivals, classroom participation, stream adoptions and fairs.	Evaluate use and/or exposure of program materials and exhibits as they help support goals of the information and education program. Record on-station organized education and outreach events.
Program contributes to fulfilling tribal trust responsibility mandates and treaty rights	Follow pertinent laws, agreements, policies and executive and judicial orders on consultation and coordination with Native American tribal governments.	Participate in annual coordination meetings between the co-managers to identify and report on issues of interest, coordinate management, and review programs (FBD process).
Implement measures for broodstock management to maintain integrity and genetic diversity Maintain effective population size of 500 adults	2,500 adults are collected throughout the spawning run in proportion to timing, age and sex composition of return	Annual run timing, age and sex composition and return timing data are collected.
Region-wide, groups are marked in a manner consistent with information needs and protocols to estimate impacts to natural and hatchery-origin fish	16.5% of all fish released will be ad-clipped and coded-wire-tagged (cwt). Blank coded-wire tags may be used to identify fish fro broodstock	Returning fish are sampled throughout their return for length, sex, and mark
Maximize survival at all life stages using disease control and disease prevention techniques. Prevent introduction, spread or amplification of fish pathogens. Follow Co-managers Fish Health Disease Policy (WDFW and NWIFC 1998).	a. Necropsies of fish to assess health, nutritional status, and culture conditions	USFWS Fish Health Pathologist inspect adult broodstock yearly for pathogens at Priest Rapids and Klickitat Hatcheries and monitor juvenile fish on a monthly basis to assess health and detect potential disease problems. As necessary, USFWS Fish Health Pathologist recommends remedial or preventative measures to prevent or treat disease, with administration of therapeutic and prophylactic treatments as necessary A fish health database will be maintained to identify trends in fish health and disease and implement fish health management plans based on findings.
	b. Release and/or transfer exams for pathogens and parasites.	1 to 6 weeks prior to transfer or release, fish are examined in accordance with the Co-managers 'Fish Health Policy

	c. Inspection of adult broodstock for pathogens and parasites.	At spawning, lots of 60 adult broodstock are examined for pathogens
	d. Inspection of off-station fish/eggs prior to transfer to hatchery for pathogens and parasites.	Controls of specific fish pathogens through eggs/fish movements are conducted in accordance to Co-managers Fish Health Disease Policy (WDFW and NWIFC 1998)

1.10.2 Risks:

Risks		
Performance Standard	Performance Indicator	Monitoring & Evaluation
Minimize impacts and/or interactions to ESA listed fish	Hatchery operations comply with all state and federal regulations. Hatchery juveniles are raised to smolt-size (50-80 fish/lb) and released volitionally from the hatchery at a time that fosters rapid migration downstream. Also, 16.5 % of all fish released will be marked to identify them from naturally produced fish and monitor straying	Monitor size, number, date of release and CWT mark quality.
Artificial production facilities are operated in compliance with all applicable fish health guidelines, facility operation standards and protocols including IHOT, Co-managers' Fish Health Policy and drug usage mandates from the Federal Food and Drug Administration	Hatchery goal is to prevent the introduction, amplification or spread of fish pathogens that might negatively affect the health of both hatchery and naturally reproducing stocks and to produce healthy smolts that will contribute to the goals of this facility.	Pathologists from USFWS Fish Health Section monitor program monthly. Exams performed at each life stage may include tests for virus, bacteria, parasites and/or pathological changes, as needed
Ensure hatchery operations comply with state and federal water quality and quantity standards through proper environmental monitoring	NPDES permit compliance YN water right permit compliance	Flow and discharge reported in monthly NPDES reports.
Water withdrawals and in-stream water diversion structures for hatchery facility will not affect spawning behavior of natural populations or impact juveniles.	Hatchery intake structures meet state and federal guidelines where located in fish bearing streams.	Barrier and intake structure compliance assessed and needed fixes are prioritized.
Hatchery operations comply with ESA responsibilities	YN completes an HGMP and is issued a federal and state permit when applicable.	
Harvest of hatchery-produced fish minimizes impact to wild populations	Harvest is regulated to meet appropriate biological assessment criteria. Mass mark juvenile hatchery fish prior to release to enable state agencies to implement selective fisheries.	Harvests are monitored by agencies and tribes to provide up to date information.

1.11.1 Proposed annual broodstock collection level (maximum number of adult fish).

The program will collect 2,500 adults returning to the Klickitat River (1:1 Male to Female).

1.11.2 Proposed annual fish release levels (maximum number) by life stage and location.

Age Class	Max. No. (Million)	Size (fpp)	Release Date	Location			
				Stream	Release Point (RKm)	Major Water-shed	Eco-province
Fingerling	2.0	50.0 - 80.0	June/July	Klickitat	RKm 27	Klickitat	Columbia Gorge
Fingerling	2.0	50.0 - 80.0	June/July	Klickitat	RKm 68	Klickitat	Columbia Gorge

1.12 Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.

Smolt to adult survival rates for URB from Priest Rapids Hatchey fall Chinook have been estimated to range from 0.29 % to 2.44 % (smolt to adult overall survival estimates for brood years 1983-87 from IHOT 1995). In comparison, from 1995 – 1999, SARs for Klickitat URB have averaged 0.34% and ranged from a low of .009% in 1995 to a high 0.73% in 1999 (RMIS Database).

Converting to local broodstock is expected to result in an average SAR of 1% which is closer to that observed for Priest Rapids Hatchery. This hatchery uses local origin fall Chinook as its brood source.

Priest Rapids Hatchery survival data can be found at: (http://www.cbr.washington.edu/cgi-bin/cwtSAR/cwtSAR.pl?action=_default&hatch=PRIEST%20RAPIDS%20HATCHERY&species=1&run=3)

1.13 Date program started (years in operation), or is expected to start.

The Klickitat Hatchery was completed in 1951 and fall Chinook production efforts have been on-going since that time. Beginning in 1986, Klickitat Hatchery production switched from the earlier tule stock to an upriver bright (URB) fall Chinook from Priest Rapids.

1.14 Expected duration of program.

On-going program. A Memorandum of Understanding (MOU) was signed on December 30, 2005 detailing the transfer of ownership and operational responsibility of the Klickitat Hatchery and the Lyle Falls and Castile Falls fishways from the WDFW to the YN. Overall goal is to maintain the Klickitat fall Chinook program at current levels for harvest augmentation for the future

1.15 Watersheds targeted by program.

The Klickitat River Subbasin and the mainstem Columbia River (harvest)

1.16 Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being addressed.

A list of the alternative approaches considered for the program is presented below. More detailed discussions to why each alternative was rejected can be found in the revised Klickitat River Anadromous Fisheries Master Plan (Yakama Nation 2008 *in draft*).

Alternative 1- Maintain Existing Program: Eliminated due to 1) imports fish from outside of the basin which increases disease risk, and 2) competition effects on spring Chinook.

Alternative 2- Transition to Fully Integrated Hatchery Program: Program requires the establishment of naturally reproducing population above Lyle Falls. Since fall Chinook were not historically present in this area, their presence may result in negative impacts to native spring Chinook.

Alternative 3- Eliminate Hatchery Production: Alternative did not meet the harvest goals identified by the YN.

Alternative 4- Restore the Natural Fall Chinook Spawning Habitat Eliminated by the Construction of The Dalles and John Day Dams: Primarily eliminated due to political infeasibility.

1.16.3) Potential Reforms and Investments

Reform/Investment 1: Upgrade of adult collection facilities at Lyle Falls.

Reform/Investment 2: Construction of the Wahkiacus Hatchery and Acclimation Facility.

Reform/Investment 3: Addition of staff, equipment, and supplies needed to implement program.

Reform/Investment 4: Release of fall Chinook lower in the Subbasin to reduce competition with listed fish species.

Reform/Investment 5: Use Klickitat River-origin adult returns as broodstock.

Section 2: Program Effects on ESA-Listed Salmonid Populations

2.1 List all ESA permits or authorizations in hand for the hatchery program.

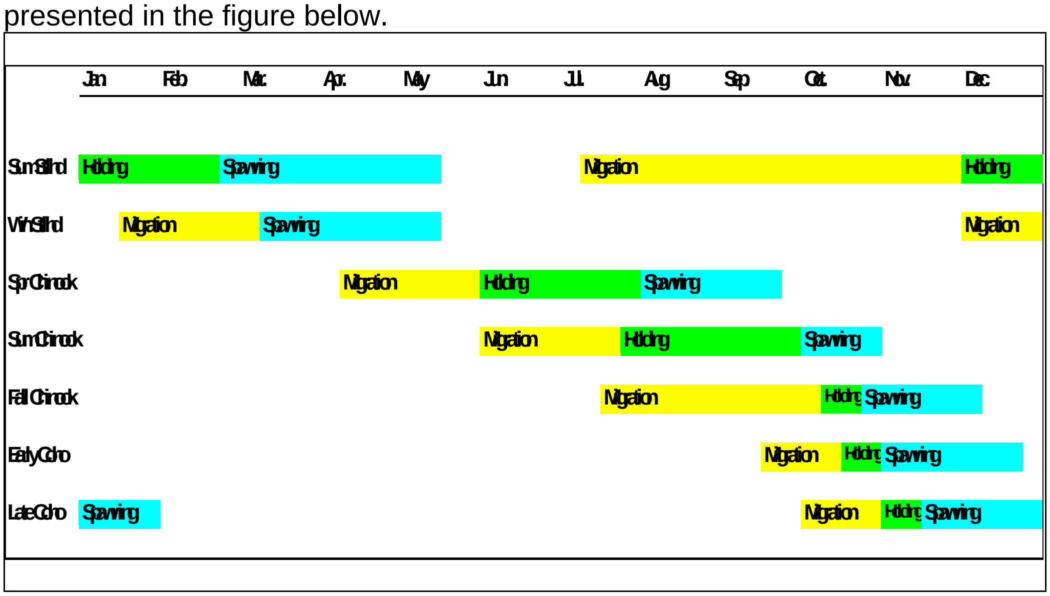
Program is described in the Biological Assessment For The Operation Of Hatcheries Funded by The National Marine Fisheries Service (March 1999), Statewide Section 6 consultation with USFWS for interactions with Bull Trout, and concurrent with this HGMP to satisfy Section 7 consultations: the YN is writing HGMPs to cover all stock/programs in the Klickitat River including fall Chinook, spring Chinook, steelhead, and coho released from Klickitat Hatchery.

2.2 Descriptions, status and projected take actions and levels for ESA-listed natural populations in the target area.

ESA listed stock	Status	Take Level	Action
Summer Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls
Winter Steelhead-Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls
Bull Trout – Natural	Threatened	Minor	Broodstock collection/trapping at Lyle Falls

2.2.1 Description of ESA-listed salmonid population(s) affected by the program.

Adult and juvenile run-timing for listed steelhead and other fish species are presented in the figure below.



The majority of the steelhead population is found from the mouth of the Klickitat River to Castile Falls. Steelhead access to areas above Castile Falls has been limited due to poor natural migration conditions at the falls. Passage has been improved at Castile Falls and steelhead abundance above this point is expected to increase. Currently, steelhead spawning is concentrated between RKm 8 and 80. Tributary spawning occurs in Swale, Swift, Summit and White Creeks, the lower Little Klickitat River and other small tributaries.

Juvenile rearing occurs in the mainstem and major tributaries. Peak smolt migration occurs in April and May; however, juvenile steelhead have been captured in traps located at Lyle Falls in all months.

Based on limited data, it is thought that an adfluvial population of bull trout may be present in the lower Klickitat River below Lyle Falls Work is on-going to determine bull trout abundance and distribution in the lower river. No bull trout have been captured in any juvenile or adult trapping facility.

Maps depicting steelhead and bull trout distribution in the Klickitat River are presented in Appendix A.

Identify the ESA-listed population(s) that will be directly affected by the program

No NMFS ESA listed fish populations will be directly affected by this program. This broodstock was not considered part of the ESU by WDFW and USFWS and was not ot essential for recovery. This stock originates from populations not considered to be part of the Lower Columbia River Chinook salmon ESU.

Identify the ESA-listed population(s) that may be incidentally affected by the program

Middle Columbia River Steelhead March 19, 1998; 64 FR 14508. Threatened
Columbia Basin DPS Bull Trout June 10, 1998 (63 FR 31647), Threatened.

2.2.2. Status of the ESA-listed population(s) affected by the program

Middle Columbia River Steelhead *(Oncorhynchus mykiss)* March 19, 1998; 64 FR 14508, Threatened.

Within the Middle Columbia River Steelhead ESU, hatchery steelhead stocks from outside the ESU are imported and released into the White Salmon (Skamania Hatchery winter and summer steelhead), Klickitat (Skamania Hatchery winter and summer steelhead) and Walla Walla (Lyons ferry), The BRT concluded that the Middle Columbia steelhead ESU is not presently in danger of extinction, but reached no conclusion regarding its likelihood of becoming endangered in the foreseeable future. Winter steelhead are reported within this ESU only in the Klickitat River and Fifteenmile Creek. Information on steelhead abundance, productivity and population growth trends is reported in NOAA 2005.

Summer and Winter Runs:
The existence of naturally spawning winter steelhead was confirmed in the early 1980s, and winter steelhead are presumed to be indigenous. Howell et al. (1985) recognized both summer and winter races of steelhead in the Klickitat Subbasin, with an adult winter steelhead migration period of January through May and a spawning period of March through June. To protect the winter run, current regulations prohibit sport fishing for steelhead in the Klickitat River from December through May and the treaty fishery is closed from January through March. Both seasons have been longer in previous years.

The years 1996-2006 comprise the most comprehensive set of steelhead spawner survey data. Redd counts over these years indicate an average escapement of 260 fish. This figure is undoubtedly an underestimate due to the inherent difficulty in conducting accurate counts during spring flow conditions. Mainstem spawning distribution is concentrated between RKm 8 and RKm 80.0, with occasional spawning above Castile Falls. Tributary spawning occurs in Swale, Wheeler, Summit, and White creeks, and the upper Little Klickitat River.

Columbia Basin DPS Bull Trout *(Salvelinus confluentu*s) June 10, 1998 (63 FR 31647), Threatened.
The Fish and Wildlife Service issued a final rule listing the Columbia River and Klamath River populations of bull trout *(Salvelinus confluentu*s) as a threatened species under the Endangered Species Act on June 10, 1998 (63 FR 31647). The Columbia River Distinct Population Segment is threatened by habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, and past fisheries management practices such as the introduction of non-native species.

The Lower Columbia Recovery Unit Team identified two core areas (Lewis and Klickitat rivers) within the recovery unit. The Klickitat Core Area includes all tributaries downstream to the confluence with the Columbia River. Recent evidence indicates both resident and adfluvial bull trout are present in the Subbasin. There are numerous confirmed and anecdotal reports of bull trout in the mainstem Klickitat River from the mouth up to the area below Castile Falls. Sizes reported are indicative of an adfluvial life history. Presence of resident populations has also been documented in the West Fork Klickitat River, Fish Lake Stream, Little Muddy Creek, Trappers Creek, Clearwater Creek, Two Lakes Stream, and an unnamed tributary to Fish Lake Stream (all within the West Fork Klickitat watershed).

The abundance of the stock in the Klickitat River is poorly known and there are insufficient data to make an assessment. However, it appears that there are very few bull trout in the lower- to mid-Klickitat drainage. Bull trout appear to be more abundant in the upper drainage where habitat conditions are more favorable.

Preliminary results of recent genetic analysis indicate that resident bull trout in the Klickitat Subbasin are genetically distinct from other Columbia tributary populations, but that fish in two West Fork Klickitat tributaries (Trappers and Clearwater creeks) do not differ significantly from each other.

The impacts of hatchery salmon and steelhead in the main Klickitat River on bull trout are unknown. Generally, in drainages colonized by anadromous salmon and steelhead, char successfully co-exist by occupying a different ecological niche. However, negative interactions such as predation may occur when hatchery fish are released near char spawning and rearing areas.

2.2.3 Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of listed fish in the target area, and provide estimated annual levels of take.

The following activities may lead to a take of listed species.

Broodstock Collection: Broodstock will be collected for this program at Lyle Falls, Klickitat Hatchery and Wahkiacus Hatchery from July through November. No ESA-listed fish mortalities (steelhead or bull trout) have been observed at the Klickitat River Hatchery for the past nine years**.** The operation of the new adult collection facilities at Lyle Falls and Wahkiacus Hatchery may result in some ESA- listed steelhead being handled because the collection facilities will be operated during time of the year when steelhead may be migrating to spawning grounds. However, as noted, the data collected at the Klickitat River Hatchery have shown that mortality is unlikely. Also, the facilities will be designed to meet NMFS passage and handling criteria which should minimize stress and associated mortality rates on fish. It is assumed that no more than 25 ESA-listed steelhead will be handled at broodstock collection facilities.

Water diversion: Water is diverted from the stream for Klickitat River Hatchery operations. This r of approximately 0.25 miles of stream habitat. The loss in habitat may result in a decrease in steelhead and bull trout abundance, although this has not been quantified, it is expected to be negligible. In addition, The Mitchell Act Intake and Screening Assessment (2002) has identified design and alternatives needed to bring existing structures in compliance with NOAA fish screening standards. YN has requested funding for future scoping, design, and construction work of a new intake system.

The new Wahkiacus Hatchery will divert approximately 24 cfs of water from the Klickitat River for rearing both fall Chinook and coho. The diversion structure will be screened to meet NMFS standards. The 24 cfs equates to approximately 1% of total river flow in May, the peak usage month. The diverted water will decrease streamflow in less than 0.25 miles of riverine habitat.

Water Quality: Both the Klickitat and Wahkiacus hatcheries will operate under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). Monthly and annual reports on water quality sampling, use of chemicals at this facility, compliance records are available from DOE. Discharges from the cleaning treatment system are monitored as follows:

Total Suspended Solids (TSS): Collected 1 to 2 times per month on composite effluent, maximum effluent, and influent samples.

Settleable Solids (SS): Collected 1 to 2 times per week on effluent and influent samples.

In-hatchery Water Temperature - Daily maximum and minimum readings. Water quality monitoring is not expected to result in the take of listed species.

Genetic introgression: Straying of fall Chinook from this program to other subbasins could result in genetic introgression with listed Chinook stocks, e.g. Snake River fall Chinook. Indirect take from straying is unknown.

Disease: Outbreaks in the hatchery may cause significant adult, egg, or juvenile mortality. Over the years, advances in rearing densities, disease prevention, and fish health monitoring have greatly improved the health of the programs at Klickitat River Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995) have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined population health. Indirect take from disease is unknown.

Release Program

Competition and Predation: According to the HSRG (2004) and Flagg et al. (2000) the potential for predation of wild salmonids by hatchery-reared smolts will depend on the size, number, and spatial distribution of both predators and prey, the functional and numerical responses of the predators, and the amount of time that predators and prey are in proximity. Busack et al. (2005) reviewed published rates of predation by juvenile hatchery salmonids on wild juvenile Chinook and found predation rates were generally low (<2% of natural population consumed). In contrast, data collected on hatchery coho predation rates on wild fall Chinook juveniles in the Lewis River were quite high (>11%) (Hawkins and Tipping 1999). The variability in study results is one reason the HSRG (2004) suggests that hatcheries monitor predation impacts resulting from hatchery releases.

In general, hatchery fish can consume fish that are 50% of their body length, however studies reviewed by Busack et al. (2005) indicated that the range may extend from approximately 38% (steelhead) to 75% (coho). NOAA Fisheries and the USFWS in a number of biological assessments and opinions were of the opinion that juvenile salmonids can consume prey at ~33% of their body length (USFWS 1994; NMFS 1999). Predation by hatchery fish on wild fish can occur anywhere the two stocks exist in space and time. Therefore, predation may not only be a concern in the stream environment, but also in the estuary and marine environments.

The site-specific nature of predation and the limited number of empirical studies that have been conducted make it difficult to predict the predation effects of this specific hatchery release. The YN is unaware of any studies that have empirically estimated the predation risks to listed fish posed by the Klickitat Hatchery programs. In the absence of site-specific empirical information, the identification of risk factors can be a useful tool for reviewing hatchery programs while monitoring and research programs are developed and implemented in the region.

Risk Factors:

Date of Release: The release date can influence the likelihood that listed species are encountered. Fall Chinook will be released in June, which is within the window when steelhead fry will be present in the mainstem Klickitat River.

Fish Size at Release: Based on the 33% of body length predation assumption and a fall Chinook size of release range of 80-100 mm, hatchery Chinook may consume listed steelhead that range in size from 26-33 mm. During the time fall Chinook are expected to be in the mainstem Klickitat River (June-July), steelhead fry (26-40 mm) will be present in the system and will be vulnerable to predation. However, steelhead fry will be occupying shallow water habitat that is not likely accessible to the larger hatchery fall Chinook; thereby reducing the chance of predation. The level of fall Chinook predation on steelhead is unknown.

Release Location and Release Type: The likelihood of predation may also be affected by the location and the type of release. Other factors being equal, the risk of predation may increase with the length of time that fish co-mingle. In the freshwater environment, this is likely to be affected by distribution of the listed species in the watershed, the location of the release and the speed at which fish released from the program migrate. Fall Chinook will be released volitionally from rearing sites located at RKm 27 (Wahkiacus Hatchery) and RKm 68 (Klickitat River Hatchery). Data collected in the mainstem Columbia River indicate that subyearling Chinook migrate at a rate of 8-24 Km per day dependent on release site. These data indicate that fall Chinook released to the Klickitat River will likely spend less than 1 week migrating out of the system once they leave the release ponds. The minimal amount of time they spend in the river system should reduce predation and competition effects to listed fish species. Additionally, as fall Chinook will not be released in tributaries, they will not affect steelhead juveniles rearing in these streams.

Residualism: To maximize smolting characteristics and minimize residualism, the YN Tribe adheres to a combination of acclimation, volitional release strategies, size, and time guidelines developed at the Cle Elum Supplementation and Research Facility (CESRF) for spring Chinook. For the fall Chinook yearling program the following actions are taken to reduce residualism:

1. Fish Condition factors, standard deviation and co-efficient of variation (CV) on lengths of fish are measured through out the rearing cycle and at release.

2. Feeding rates and regimes throughout the rearing cycle are programmed to satiation feeding to minimize size variations and reprogrammed as needed to achieve goals for smolt size at time of release.

3. Based on past history, fish have reached a size and condition that indicates a smolted condition at release.

4. Releases occur within known time periods of wild fish migration.

5. Releases from acclimation ponds are volitional with large proportions of the populations moving out initially with the remainder of the population vacating within a couple of days.

Migration Corridor/Ocean:

The Columbia River hatchery production ceiling, called for in the Proposed Recovery Plan for Snake River Salmon of approximately 197.4 million fish (1994 release levels), has been incorporated by NOAA-Fisheries into their recent hatchery biological opinions to address potential mainstem corridor and ocean effects, as well as other potential ecological effects from hatchery fish. Although hatchery releases occur throughout the year, approximately 80% occur from April to June and Columbia River mainstem out-migration occurs primarily from April through August (www.fpc.org). It is unknown to what extent listed fish are available both behaviorally and spatially on the migration corridor. Once in the main stem Columbia River, Witty et al. (1995) has concluded that predation by hatchery fish on wild salmonids does not significantly impact naturally produced fish survival in the Columbia River migration corridor. In a study designed to define the migrational characteristics of Chinook salmon, coho salmon, and steelhead trout in the Columbia River estuary, Dawley et al (1984), found the average migration rates for subyearling Chinook, yearling Chinook, and coho salmon and steelhead, were 22, 18, 17, and 35 RKm/d respectively. There appear to be no studies demonstrating that large numbers of Columbia system smolts emigrating to the ocean affect the survival rates of juveniles in the ocean in part because of the dynamics of fish rearing conditions in the ocean and an inability to measure.

Monitoring:

1. Smolt Monitoring- Smolt traps above Castile Falls, near the Klickitat Hatchery and lower Klickitat River will be used to monitor hatchery fish migration timing and abundance.
2. Adult trapping at Lyle Falls, Castile Falls and Klickitat River Hatchery will be monitored for impacts to listed adults.

These activities have the potential to harass, kill, or injured handled fish as evidenced by the data presented in the following table:

The number of juvenile steelhead handled and resultant mortality at the Lyle Falls rotary screw trap (2003-2006).

	Workups		Tallies		Grand Totals		
Year	Morts	Total Handled	Morts	Total Handled	Morts	Total Handled	% mortality
2003	8	764	64	515	72	1279	5.6%
2004	1	486	110	2054	111	2540	4.4%
2005	1	379	8	817	9	1196	0.8%
2006	0	81	0	35	0	116	0%
Totals					192	5131	3.7%

Research:

None proposed.

Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

Estimated listed salmonid take levels by hatchery activity.

Steelhead

ESU/Population	Middle Columbia River Steelhead
Activity	Klickitat Hatchery Spring Chinook Program
Location of hatchery activity	Klickitat R. Hatchery
Dates of activity	May – September
Hatchery Program Operator	WDFW

Type of Take	Annual Take of Listed Fish by life Stage (number of fish)			
	Egg/Fry	Juvenile /Smolt	Adult	Carcass
Observe or harass (a)				
Collect for transport (b)				
Capture, handle, and release (c)		5,000*	25**	
Capture, handle, tag/mark/tissue sample, and release (d)				
Removal (e.g., broodstock) (e)			40	
Intentional lethal take (f)				
Unintentional lethal take (g)				
Other take (indirect, unintentional) (h)				

* Past juvenile trapping operations have captured ~5,000 steelhead parr and smolts.
**Although steelhead have not been taken during past hatchery practices, it is anticipated that adult steelhead will be collected and handled at the new facilities at Lyle Falls and Wahkiacus Hatchery. No mortality is expected from these operations.

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.

b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
c. Take associated with weir or trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
h. Other takes not identified above as a category.

Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.
Any mortality from this operation or other Klickitat River Hatchery operations will be communicated to Fish program staff for additional guidance. For other listed species, if significant numbers of wild salmonids are observed to be negatively impacted by this operation, staff will inform the YN lead biologist who will communicate concerns to NOAA staff. Mitigation recommendations made by NOAA and the co-managers will then be implemented.

Section 3: Relationship of Program to Other Management Objectives

3.1 Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. *Hood Canal Summer Chum Conservation Initiative*) or other regionally accepted policies (e.g. the *NPPC Annual Production Review* Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.

For ESU-wide hatchery plans, the plant of fall Chinook to the Klickitat River is consistent with:

- 1999 Biological Opinion on Artificial Propagation in the Columbia River Basin (NMFS 1999)
- Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1995)
- The *U.S. v. Oregon* Columbia River Fish Management Plan
- Columbia River Basin Fish and Wildlife Program (http://www.nwcouncil.org/library/2000/2000-19/Default.htm)
- NPPC Annual Production Review
- Principles and Recommendations of the HSRG (HSRG 2004)
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- Klickitat River Anadromous Fisheries Master Plan (2008, in draft)
- Draft Klickitat Subbasin Recovery Plan for Middle Columbia River Steelhead ESU. (NOAA-Portland 2007)

The current program has been made consistent with and aligned with the following plans and policies to the extent possible:

Yakima/Klickitat Fisheries Project (YKFP or Project) - Encompasses both the Yakima and Klickitat subbasins. It is the only major project in the Northwest Power and Planning Council's (NPPC) Fish and Wildlife Program that covers two major subbasins, each within a separate province. Since inception, the Yakama Nation has managed Project operations in both subbasins as one undertaking. By consolidating management for both subbasins into a single management unit, the YN has ensured Project efficiency at all levels. As necessitated by the NPPC's provincial proposal format, this proposal "unbundles" Project operation and maintenance activities. It covers the Klickitat Subbasin only. The YKFP is a supplementation project designated by the Northwest Power Planning Council's as the principal means of protecting, mitigating, and enhancing the anadromous fish populations in the Yakima and Klickitat subbasins (http://www.ykfp.org/).

Klickitat Master Plan -Prepared by Yakama Nation, this master plan addresses proposed facilities, production protocols, monitoring and evaluation, and habitat improvements needed to manage spring and fall Chinook salmon, coho, steelhead, bull trout, and Pacific Lamprey in the Klickitat Subbasin.

U.S. v Oregon and the Columbia River Fish Management Plan (CRFMP)

Genetic Manual and Guidelines for Pacific Salmon Hatcheries in Washington. These guidelines define practices that promote maintenance of genetic variability in propagrated salmon (Hershberger and Iwamoto 1981). Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 5, IHOT 1995).

Spawning Guidelines for Washington Department of Fisheries Hatcheries. Assembled to complement the above genetics manual, these guidelines define spawning criteria to be use to maintain genetic variability within the hatchery populations (Seidel 1983). Also, *Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries* (Genetic Policy Chapter 7, IHOT 1995).

Stock Transfer Guidelines. This document provides guidance in determining allowable stocks for release for each hatchery. It is designed to foster development of locally-adapted broodstock and to minimize changes in stock characteristics brought on by transfer of non-local salmonids (WDF 1991).

Fish Health Policy in the Columbia Basin. Details hatchery practices and operations designed to stop the introduction and/or spread of any diseases within the Columbia Basin.

National Pollutant Discharge Elimination System Permit Requirements (NPDES). This permit sets forth allowable discharge criteria for hatchery effluent and defines acceptable practices for hatchery operations to ensure that the quality of receiving waters and ecosystems associated with those waters are not impaired.

3.2 List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates.

The program described in this HGMP is consistent with the following agreements and plans:

- The Columbia River Fish Management Plan
- Klickitat Master Plan
- Yakima/Klickitat Fisheries Project (YKFP or Project)
- U.S. vs. Oregon court decision
- Production Advisory Committee (PAC)
- Technical Advisory Committee (TAC)
- Integrated Hatchery Operations Team (IHOT) Operation Plan 1995 Volume III.
- Pacific Northwest Fish Health Protection Committee (PNFHPC) (http://www.fws.gov/pnfhpc/)
- In-River Agreements: State, Federal, and Tribal representatives
- Northwest Power Planning Council Sub Basin Plan (http://www.nwcouncil.org/fw/subbasinplanning/klickitat/plan/)
- Memorandum of Understanding Joint Operating Agreement for the Klickitat Hatchery (WDFW and YIN)

3.3 Relationship to harvest objectives.

The *U.S. v. Oregon* Columbia River Fish Management Plan recognized the importance of tribal harvest in the Klickitat River by mandating releases of 4.0 million fall Chinook (http://www.critfc.org/legal/crfmp88.html). The YN has an overall objective of providing 18,000 adults for harvest. The fall Chinook program has provided a steady contribution to tribal commercial fisheries. A summary of fall Chinook escapement and harvest estimates are provided below in Section 3.3.1 for marine, Columbia River and Klickitat River. The data indicate that the fall Chinook program has provided, on average, approximately 19,500 fish for harvest.

3.3.1. Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years, if available.

The largest harvest of Klickitat Hatchery fall Chinook is in the Canadian Troll fishery, but they are also harvested in the Canadian sport and net fisheries, the Washington/Oregon coastal sport and troll fisheries, Alaskan fisheries, Columbia River tribal fisheries, and freshwater sport fisheries. Harvest rates have not been estimated for Klickitat Hatchery fall Chinook. They were originally the product of Up-River Bright (URB) fall Chinook and it is likely that their harvest profiles are similar. The total ocean and freshwater adult equivalent harvest rates for URB fall Chinook for return years 1989-1996 ranged from 33% to 73%. The 1989-1993 average was 62% and the 1991-1996 average was 48%. Terminal harvest rates are expected to increase as the program will be designed to eliminate, to the extent possible, fall Chinook spawning above Lyle Falls.

Estimated harvest and run size information for Klickitat River fall Chinook (adults and jacks, early-fall/tule and URB stocks combined)(1986-2005).

Year	Marine[1] Harvest	Columbia R. Mouth Return	Col. R. Harvest[2]		Bonn. Passage Loss[3]	Klickitat R. Mouth Return[4]	Klickitat Harvest[4]	Total Harvest
			Zones 1-5	Zone 6				
1986		25,693	9,017	7,449	461	8,766	8,104	24,570
1987		5,489	2,209	1,344	97	1,839	1,132	4,685
1988		3,693	1,689	875	56	1,073	1,073	3,637
1989	9,295	14,174	6,738	2,861	229	4,346	1,754	20,648
1990	15,270	12,817	4,109	2,952	288	5,468	1,574	23,906
1991	3,553	10,349	2,763	1,547	302	5,737	2,791	10,654
1992		7,687	1,694	1,169	241	4,583	1,148	4,011
1993	23,267	6,520	1,339	1,407	189	3,586	1,118	27,130
1994	1,051	6,686	296	731	283	5,377	1,249	3,326
1995	3,446	5,282	308	539	222	4,213	1,470	5,763
1996	4,562	13,924	1,680	1,541	535	10,168	3,811	11,594
1997	4,196	16,664	2,257	1,839	628	11,940	3,612	11,904
1998	3,735	18,070	2,332	1,458	714	13,566	3,504	11,029

1999	5,525	23,240	2,807	1,585	942	17,906	3,335	13,252
2000	4,303	21,372	3,205	2,980	759	14,428	4,939	15,427
2001	3,761	12,653	2,304	2,637	386	7,327	2,897	11,598
2002	15,065	33,609	5,901	7,219	1,024	19,465	7,730	35,915
2003	22,260	48,145	9,497	8,229	1,521	28,899	3,852	43,837
2004	25,775	22,676	3,235	3,580	793	15,068	8,885	41,475
2005	50,702	19,977	2,878	3,533	678	12,887	8,109	65,222
Avg	12,235	16,436	3,313	2,774	517	9,832	3,604	19,479

1. Derived from Regional Mark Information System (RMIS) recovery year data for marine and freshwater coded-wire tag (CWT) recoveries of fall Chinook released in the Klickitat River.
2. Derived from *U.S. v. Oregon* Technical Advisory Committee reports.
3. Assume 5% passage attrition ascending Bonneville Dam and through the reservoir.
4. YN and WDFW database estimates.

3.4 Relationship to habitat protection and recovery strategies.

The program described in this HGMP is consistent with the following habitat and protection strategies:

Klickitat Subbasin Recovery Plan for the Mid Columbia ESU- This plan provides habitat strategies to be used to recover ESA listed steelhead in the Klickitat Subbasin. The hatchery program has considered current and future habitat conditions in sizing program and defining release locations

Yakama Nation Fisheries Program (YNFP):
The Lower Klickitat Riparian and In-Channel Habitat Enhancement Project is a BPA-funded watershed restoration project implemented by the Yakama Nation Fisheries Program (YNFP). The YNFP is working in coordination with WDFW, Natural Resources Conservation Service (NRCS), and the Central Klickitat Conservation District. The project was proposed under the Northwest Power Planning Council's Fish and Wildlife Program and funded by BPA in 1997. Initial project restoration projects were located within the Swale Creek and Little Klickitat River watersheds. Included in the project scope of work are in-stream structural modifications, re-vegetation of the riparian corridor, construction of sediment retention ponds to provide late-season flow to the creek and exclosure fencing to prevent channel degradation from livestock. A monitoring program has been initiated to document project success and guide future restoration activities. The second phase of the project will use EDT modeling output to guide and prioritization restoration activities.

Klickitat River Anadromous Fisherires Master Plan:
The Master Plan is currently in preparation the Yakama Nation. It addresses proposed goals and objectives, facilities, production, monitoring and evaluation, and habitat improvements needed to manage spring and fall Chinook salmon, coho salmon, steelhead, and Pacific Lamprey in the Klickitat Subbasin (Yakama Nation 2008 *in draft*).

Subbasin Planning and Salmon Recovery:
The fall Chinook program has been changed to reduce adult escapement to stream reaches upstream of Lyle Falls. This action should reduce competition

and predation effects on native spring Chinook, thereby making habitat actions more effective at increasing spring Chinook abundance and productivity (NPPC 2004).

Habitat Treatment and Protection:
WDFW, in partnership with YN, has conducted or is conducting habitat inventories within the Klickitat Subbasin. Ecosystem Diagnosis and Treatment (EDT) compares habitat today to that of the Subbasin in a historically unmodified state. It creates a model to predict fish population outcomes based on habitat modifications. WDFW is also conducting a Salmon Steelhead Habitat Inventory Assessment Program (SSHIAP) which documents barriers to fish passage. WDFW's habitat program issues hydraulic permits for construction or modifications to streams and wetlands. This provides habitat protection to riparian areas and actual watercourses within the watershed.

Limiting Factors Analysis

A WRIA 30 (Klickitat Basin) habitat limiting factors report (LFA) has been completed by the Washington State Conservation Commission. This limiting habitat factors analysis was conducted pursuant to RCW 75.46 (Salmon Recovery). The purpose of this analysis was "to identify the limiting factors for salmonids" where limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon." It was intended that a locally based habitat project selection committee use the findings of this analysis to prioritize appropriate projects for funding under the state salmon recovery program. This analysis may also be used by local organizations and individuals interested in habitat restoration to identify such projects (Washington State Conservation Commission 1999).

The Strategic Plan For Salmon Recovery (HB 2496): Klickitat County functions as the lead entity for this plan which includes Klickitat major creeks, Big White Salmon and Little White Salmon. This document provides the prioritized actions addressing limiting factors from which the Salmon Recovery Funding Board projects are ranked for consistency and effectiveness.

3.5 Ecological interactions.

Below are discussions on both negative and positive interactions relative to the fall Chinook program.

(1) Salmonid and non-salmonid fishes or species that could negatively impact the program:

Klickitat fall Chinook smolts are subject to predation after release throughout the entire migration corridor from the Subbasin to the mainstem Columbia River and estuary. Northern pikeminnows and introduced spiny rays as well as a variety of bird species including gulls, mergansers, cormorants, belted kingfishers, great blue herons and night herons are among those preying on fall Chinook smolts. River otters can take a heavy toll on migrating smolts while returning adults are preyed upon by harbor seals, sea lions, and Orcas. Large numbers of northern pikeminnows congregate at the mouth of the Klickitat River. Predation on the juvenile Chinook outmigrants by the northern pikeminnow may have a negative impact on this stock. Avian predation by common mergansers, double crested cormorants, and (especially) Caspian terns also pose a large threat.

(2) Salmonid and non-salmonid fishes or species that could be negatively impacted by the program:

Natural salmon and steelhead populations that co-exist in local tributary areas and the Columbia River mainstem corridor areas could be negatively impacted by program fish. Of primary concern are the ESA-listed endangered and threatened salmonids: Snake River fall-run Chinook salmon ESU (threatened); Snake River spring/summer-run Chinook salmon ESU (threatened); Lower Columbia River Chinook salmon ESU (threatened); Upper Columbia River spring-run Chinook salmon ESU (endangered); Columbia River chum salmon ESU (threatened); Snake River sockeye salmon ESU (endangered); Upper Columbia River steelhead ESU (endangered); Snake River Basin steelhead ESU (threatened); Lower Columbia River steelhead ESU (threatened); Middle Columbia River steelhead ESU (threatened); and the Columbia River distinct population segment of bull trout (threatened). Listed fish can be impacted through a complex web of short- and long-term processes and over multiple time periods which makes evaluation of the net effect difficult.

3) Salmonid and non-salmonid fishes or other species that could positively impact the program.

Other wild and hatchery salmonids may provide nutrients to the Klickitat River upon their return as adults. These carcasses may increase stream productivity, which in turn may increase food abundance for Chinook.

4) Salmonid and non-salmonid fishes or species that could be positively impacted by the program.

Aquatic and terrestrial species that consume salmonids will benefit from the continued release of fish from this program. Common species that may benefit include northern pikeminnow, smallmouth and largemouth bass, gulls, mergansers, cormorants, belted kingfishers, great blue herons and night herons, harbor seals, sea lions, river otters, bear, and killer whales (Orcas). Additionally, salmon carcasses act as a source of fertilizer that benefits riparian plants which, in turn, provide nutrients back to the stream.

Section 4. Water Source

4.1 Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile and natural limitations to production attributable to the water source.

<u>Klickitat Hatchery</u>

The Klickitat River is the homing water source for the target population. The water flowing into Klickitat Hatchery Pond 24 is re-used rearing water from the hatchery and is made up primarily of spring water from Indian Ford A Springs originating across the river from the hatchery. This is the same spring water, which is used for the incubation and early rearing of all juveniles. In the spring, river water is introduced for acclimation for this pond. The remaining population is reared in Pond 26 which is supplied with spring water from Wonder Springs which is approximately one-half mile downstream and across the river from the main hatchery. These water sources flow naturally into the Klickitat River and make up a part of its total volume; however, they were not historically available as separate spawning/rearing waters.

<u>Wahkiacus Hatchery</u>

This facility will use up to 24 cfs of river water from the Klickitat River. Water quality in the area is acceptable for spring and early summer acclimation. High turbidity during storm events may cause short-term problems in juvenile fish rearing and feeding.

4.2 Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

Hatchery water withdrawal	*Klickitat Hatchery*: Water rights total 6000 – 8000 gpm from the gravity intake with another 4,000 pumped from the river. Water rights will be formalized through trust water rights from the Department of Ecology. Monitoring and measurement of water usage is reported in monthly NPDES reports. *Wahkiacus Hatchery*: New water rights will be obtained for this site.
Intake/Screening Compliance	Intake structures will be designed and constructed to NMFS specifications at Wahkiacus Hatchery. The Mitchell Act Intake and Screening Assessment (2002) identified the design and alternatives needed to get existing structures at Klickitat Hatchery in compliance with NMFS fish screening standards. From the assessment, YN has been requesting funding for future scoping, design, and construction work of a new intake system.
Hatchery effluent discharges. (Clean Water Act)	Both facilities will operate under the “Upland Fin-Fish Hatching and Rearing” National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). WAG 13-5002. Monthly and annual reports on water quality sampling, use of chemicals, and compliance records will be available from the Washington DOE. Discharges from the cleaning treatment system are monitored as follows:

	Total Suspended Solids (TSS): Collected 1 to 2 times per month on composite effluent, maximum effluent, and influent samples. *Settleable Solids (SS)*: Collected 1 to 2 times per week on effluent and influent samples. *In-hatchery Water Temperature* - Daily maximum and minimum readings. Acclimation ponds will be designed to handle and process effluent during cleaning operations.

Section 5. Facilities

5.1 Broodstock collection facilities (or methods).

Broodstock to be collected at Lyle Falls, Wahkiacus Hatchery and Klickitat River Hatchery. Adults will be collected randomly throughout the entire run. Real-time DNA samples will be collected on adults collected in the Klickitat River to ensure that spring Chinook and out-of-basin origin fish are not used as broodstock.

Adults will be transported by truck to holding facilities located at Klickitat or Wahkiacus hatcheries using protocols defined in Hager and Costello (1999). Time in transport will be less than 1 hour.

5.2 Fish transportation equipment (description of pen, tank, truck, or container used).

Adults and juveniles are trucked to holding and acclimation sites.

5.3 Broodstock holding and spawning facilities.

Adult holding ponds at Klickitat and Wahkiacus hatcheries are/will be fed with a combination of river, well and spring water.

See Priest Rapids HGMP for data on adult holding at this facility.

5.4 Incubation facilities.

Incubation facilities at Wahkiacus and Klickitat hatcheries use well or spring water for incubation. Klickitat Hatchery has 72 stacks of FAL Heath incubators for incubation and hatching. Stack incubators are loaded at 6000-8000 eggs/per tray for hatching. Removal of dead eggs, accurate enumeration, and loadings are adjusted during this time.

See Priest Rapids HGMP for data on incubation facilities at this hatchery.

5.5 Rearing facilities.

Fall Chinook will be reared at both Wahkiacus and Klickitat hatcheries. At both facilities, fry will be ponded and released on-station.

Ponds (No.)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Flow (gpm)
11	concrete	3500	100	10	3.5	250
26	Hypalon Release Pond	29925	190	45	3.5	55
24	earthen release pond	24500	175	40	3.5	6000

Fall Chinook fry are ponded in raceways. In mid-March the fingerlings are transferred to release ponds 24 - 26 at the Klickitat Hatchery until release at 80 fpp. The hypalon pond is gravel bottomed and vinyl sided, while Pond 24 is an earthen/gravel pond.

At Wahkiacus, eggs will be incubated, fry will be “first fed” and fingerlings will be reared to release size. Fish will be moved from smaller to larger rearing units as they grow.

5.6 Acclimation/release facilities.

Initially, the majority of the fall Chinook will be transferred as eyed-eggs from Priest Rapids Hatchery to either Klickitat or Wahkiacus hatcheries in December and January. The fish will be reared on a combination of well and river water. Partial rearing on parent river water, or acclimation for several weeks, is done to ensure strong homing to the hatchery, thus reducing the stray rate to natural populations. Fish will be allowed to migrate volitionally from rearing ponds at both Wahkiacus and Klickitat River hatcheries.

As the program is shifted to local broodstock, eyed-egg transfers from Priest Rapids will be eliminated.

5.7 Describe operational difficulties or disasters that led to significant fish mortality.

Currently, the 4.0 million target release strains facility operations, making best rearing practices difficult to implement. The new Wahkiacus Hatchery will alleviate this problem by increasing rearing capacity. However, there has been no instance of large-scale fish loss for the current program.

5.8 Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality.

Potential Hazard	Risk Aversion Measure
Equipment failure/Water loss	Both facilities will have multiple water sources available. At Klickitat Hatchery, there is a main river gravity water feed system, three torpedo type river pumps, and several springs available. Backup generator system is automatic in case of power loss. Wahkiacus Hatchery will have both river intake and well water sources.
Flooding/Water Loss	Both facilities are sited to minimize the risk of catastrophic fish loss from flooding and equipped with low water alarm probes in strategic locations to prevent fish loss due to loss of water. Alarm systems are monitored 24/7 with staff available on-station to respond to problems. At Wahkiacus, under 100-year flood conditions, pond berms may be overtopped. Fish could be washed out of the system during these events. Debris entering the ponds will need to be removed and ponds cleaned and repaired.
Disease Transmission	USFWS fish health guidelines are followed. USFWS fish health pathologists conduct inspections monthly and problems are managed promptly to limit mortality and reduce possible disease transmission.

Section 6. Broodstock Origin and Identity

6.1 Source.

Source is Priest Rapids Hatchery and the Klickitat River. Broodstock used in the program will be collected at random throughout the run-at-large at Lyle Falls, Klickitat Hatchery, Wahkiacus Hatchery, and Priest Rapids Hatchery.

As the project progresses, only adult fall Chinook returning to the Klickitat River will be used for broodstock.

6.2.1 History.

Introductions of fall-run Chinook salmon into the Klickitat River began in 1946 (Marshall et al. 1995), and although a hatchery broodstock was established, tule stocks from various facilities continued until 1986. Beginning in 1986, Klickitat Hatchery production switched from the tule stock to an upriver bright (URB) fall Chinook. Currently, 4 million hatchery URB smolts are released on-station annually, primarily for harvest augmentation. Eyed eggs currently are transferred from Priest Rapids Hatchery to the Klickitat Hatchery for final rearing. There is no capture of fall-run Chinook salmon adults at Klickitat Hatchery and eggs are imported yearly from Priest Rapids, Little White Salmon, or Bonneville hatcheries. A naturally spawning population of fall-run Chinook salmon exists in the Klickitat River; it appears to be a hybrid of tule and upriver bright stocks. Genetic analysis of naturally spawning Klickitat fall Chinook sampled from 1991 to 1994 showed them to be very similar genetically to URB Chinook at Priest Rapids Hatchery and in Hanford Reach and they were closely associated with URB populations at Bonneville and Little White Salmon hatcheries and in the Yakima River (Marshall 2000).

Hatchery sources have included:

Broodstock Source	Origin	Year(s) Used	
		Begin	End
Priest Rapids Fall Chinook Hatchery	H	1995	Present
Snake River Mix Fall Chinook Hatchery	H	1995	1999
Bonneville Fall Chinook Hatchery	H	1997	2000
Little White Salmon Fall Chinook Hatchery	H	1997	1999

6.2.2 Annual size.

Priest Rapids Hatchery collects 13.5 million eggs from 5,000 - 6,000 adults (1:1 ratio of males and females). Of these, 4.5 million eyed eggs have been historically transferred to Klickitat Hatchery for this program. The 4.5 million egg-take will continue; however, the program now calls for collecting as large a proportion as possible from adults returning to the Klickitat River with the goal of completely eliminating egg-transfers from Priest Rapids. This action will reduce disease risks associated with the importation of eggs from outside of the Subbasin.

6.2.3 Past and proposed level of natural fish in the broodstock.

Estimates of the proportion of wild fish used as broodstock are not known. However, because broodstock were collected at Priest Rapids Hatchery, Klickitat River origin fish have never been used as broodstock.

The new program will use adult fall Chinook that return to the Subbasin as broodstock. Both marked and unmarked fish may be incorporated into the hatchery program. However, because a native run of fall Chinook does not exist above Lyle Falls, the number of natural-origin fish available to the program is limited. Therefore, the program does not establish a goal for the number or proportion of natural-origin fish used as broodstock.

6.2.4 Genetic or ecological differences.

Tule fall Chinook are not indigenous to the Klickitat Subbasin. Hatchery plants (tule) from outside the Subbasin first occurred in 1946. Releases from the Klickitat Hatchery began in 1952 and continued until 1986. Releases have included stocks from Cowlitz, Toutle, Kalama, Washougal, Bonneville, Cascade, and Ringold hatcheries. The Klickitat fall Chinook program was originally developed to rear tule fall Chinook from the Spring Creek Hatchery. When the Spring Creek program failed to provide the necessary eggs, the program was changed to URB Chinook. The URB Chinook program was intended to provide a better quality fish for the tribal terminal fishery in the lower Klickitat River.

6.2.5 Reasons for choosing.

Using Klickitat River origin fish is expected to increase survival rates and reduce genetic risks to the natural population (HSRG 2004).

6.3 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices.

Using native Klickitat River adults for broodstock is expected to minimize straying into adjacent subbasins, thereby reducing genetic risks to ESA -listed Chinook populations in the Columbia and Snake rivers.

Section 7. Broodstock Collection

7.1 Life-history stage to be collected (adults, eggs, or juveniles).

Adults

7.2 Collection or sampling design

Adults will be collected at random throughout the entire upstream migration period. Fish will be collected at Lyle Falls, Klickitat Hatchery, Wahkiacus Hatchery, and at Priest Rapids Hatchery.

Broodstock collection at Priest Rapids will be phased out over time as the program is converted to local broodstock.

7.3 Identity.

Klickitat River and URB at Priest Rapids Hatchery. Program goal to eventually collect all broodstock from the Klickitat River.

7.4 Proposed number to be collected:

7.4.1 Program goal (assuming 1:1 sex ratio for adults):

A maximum of 2,500 adults will be collected for broodstock.

7.4.2 Broodstock collection levels for the last twelve years (e.g. 1990-2001), or for most recent years available.

Data below is from Priest Rapids Hatchery. Actual broodstock used is approximately 5,720 per year.

Year	Adults		
	Females	Males	Jacks
Planned	4000	2000	40
1990	2276	1203	451
1991	1533	1103	1088
1992	2615	3482	1161
1993	3732	5231	277
1994	7801	6018	752
1995	4664	6076	982
1996	5044	9236	131
1997	6168	4668	1625
1998	4216	10858	1101
1999	11386	11715	258
2000	4099	3136	443

2001	4253	10280	784
2002	4284	7718	399
2003	3574	5352	784

7.5 Disposition of hatchery-origin fish collected in surplus of broodstock needs.

Surplus adults will be distributed to tribal members for ceremonial and subsistence purposes.

7.6 Fish transportation and holding methods.

Fall Chinook captured at Lyle Falls will be transported by truck to either Wahkiacus or Klickitat hatcheries following protocols identified in Hager and Costello (1999). Fall Chinook that swim in to either hatchery will be diverted to adult holding ponds. Adult holding ponds are supplied with a combination of river, well, and spring water.

Fall Chinook collected in the Priest Rapids Hatchery trap are transported by tank truck one mile to the adult holding pond on the main hatchery grounds where they are held for spawning. The holding pond is supplied with 100 % well water to maintain adult fish in cooler water than available from the river. The adult pre-spawning survival objective for the program is 90 %. No takes of ESA-listed fish occur through the broodstock holding operation. See Priest Rapids Fall Chinook HGMP.

7.7 Describe fish health maintenance and sanitation procedures applied.

USFWS fish health protocols will be followed for adult holding.

7.8 Disposition of carcasses.

Carcasses of fall Chinook spawned through the programs will be buried at a local landfill. If they receive certification by USFWS, they may be planted as part of a nutrient enhancement project in the Klickitat River Subbasin.

7.9 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program.

All listed species collected in traps will released immediately back to the stream. Adult trapping facilities are designed to meet NMFS standards to minimize impacts to anadromous salmonids.

Converting to local broodstock is expected to reduce adult straying rates to other subbasins, thereby decreasing genetic risks to other Chinook populations.

Section 8. Mating

8.1 Selection method.

The spawning protocol mandates the use of a spawning population of at least 500 adults. Spawners are selected and mated randomly from the population maintained in the hatchery holding pond. Fish are spawned throughout the entire run to help ensure that the run timing for the stock is maintained.

8.2 Males.

Jacks will be used in proportion to that observed in the natural run.

8.3 Fertilization.

A 1:1 male to female ratio will be used for fertilization.

8.4 Cryo-preserved gametes.

Cryo-preserved gametes are not used.

8.5 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme.

DNA samples will be collected on all adult fish collected for broodstock. Non-native Chinook will not be used for broodstock.

No listed fish will be spawned or mated as part of this program.

Section 9. Incubation and Rearing.

9.1.1 Number of eggs taken and survival rates to eye-up and/or ponding.

Historically, eggs are taken from fish spawned at Priest River Hatchery. Data below is from Priest River Hatchery. Once "eyed", 4.5 million eggs will be transferred to Klickitat Hatchery.

Year	Egg Take	Eyed-Ponding Survival (%)
1995	17,345,900	98.10
1996	14,533,500	99.13
1997	17,007,000	99.24
1998	13,981,300	98.09
1999	16,089,600	98.72
2000	15,349,500	97.89
2001	13,389,500	94.28
2002	13,732,550	99.54
2003	13,820,500	98.90

At Klickitat Hatchery, eyed egg to ponding survival is approximately 98.2%. A similar rate is expected for the new Wahkiacus Hatchery.

9.1.2 Cause for, and disposition of surplus egg takes.

Variability in fecundity and egg survival may result in surplus eggs being collected at the Wahkiacus Hatchery. Surplus eggs may be released or destroyed dependent on the results of consultations with the co-managers.

9.1.3 Loading densities applied during incubation.

Klickitat Hatchery has 72 stacks of FAL Heath incubators for incubation and hatching. Stack incubators are loaded at 6000-8000 eggs/per tray for hatching. Removal of dead eggs, accurate enumeration and loadings are adjusted during this time. See section 5.4 for load and hatching criteria. Integrated Hatchery Operations Team (IHOT) species-specific incubation recommendations are followed for water quality, flows, temperature, substrate and incubator capacities. Wahkiacus will have similar facilities**.**

9.1.4 Incubation conditions.

Integrated Hatchery Operations Team (IHOT) species-specific incubation recommendations will be followed for water quality, flows, temperature, substrate, and incubator capacities at both the Wahkiacus and Klickitat hatcheries.

Harmful silt and sediment is cleaned from incubation systems regularly while eggs are monitored to determine fertilization and mortality. Incubation water is from Indian Ford A Springs located across the river from the hatchery. Temperature is monitored by thermograph and recorded; temperature units (TU) are tracked for embryonic development. Dissolved oxygen content is monitored and has been at acceptable levels of saturation with a minimum criteria of 8 parts per million (ppm). When using artificial substrate, vexar, or bio-rings, egg densities within incubation units are reduced by 10%.

9.1.5 Ponding.

Fall Chinook fry are transferred from Heath trays for ponding upon button-up and swim-up. Fry are ponded when: a visual inspection of the amount of yolk sac remaining with the yolk slit closed to approximately 1 millimeter wide (approximately 1,600 – 1,800 temperature units) or based on (95% yolk absorption) KD factor. The mean weight for fry ponded is 700-800 fpp. At this time, fry are transferred to raceways for rearing.

9.1.6 Fish health maintenance and monitoring.

USFWS fish health guidelines are followed. Hatchery staff conducts daily inspection, visual monitoring and sampling from eye, fry fingerling and sub-yearling stages. Potential problems are immediately communicated to the USFWS fish health specialist. In addition, fish health specialists conduct inspections monthly. Potential problems are managed promptly to limit mortality and reduce possible disease transmission. At spawning, eggs are water-hardened in iodophor as a disinfectant. Formalin (37% formaldehyde) is periodically dispensed into water supplied to the incubators and raceways to control fungus growth on eggs. Formalin may also be used on parasite loads on juvenile salmon, if recommended by a fish health specialist. Treatment dosage and duration varies by life-stage and condition being treated. All fish disease control procedures are conducted consistent with USFWS Policy for fish reared in the Klickitat and WDFW Policy at Priest Rapids Hatchery.

9.1.7 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to <u>listed</u> fish during incubation.

Listed fish are not incubated for this program.

9.2.1 Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years, or for years dependable data are available.

Year	Fry-fingerling Survival (%)
1995	96.50
1996	98.86
1997	98.78
1998	99.19
1999	99.40
2000	96.13
2001	98.69
2002	97.72
2003	98.43

At Klickitat Hatchery, eyed egg to smolt release survival for the last nine years has averaged 91%.

9.2.2 Density and loading criteria (goals and actual levels).

The pond loading densities maintained at the Klickitat Hatchery are consistent with those recommended by Piper et al. (1982; 6 lb/gpm and 0.75 lb/ft^3) and Banks (1994; 0.125 lb/ft^3/in) (BAMP 1998).

Fry are transferred from the Heath incubation trays to vinyl raceways for start feeding and continued rearing. The raceways have flow through water circulation.

9.2.3 Fish rearing conditions.

Fish are to be reared on a combination of river, spring and well water at Klickitat and the new Wahkiacus hatcheries. Information provided below is for the Klickitat Hatchery, but will apply to the Wahkiacus Hatchery as well once this facility is constructed.

Temperature, dissolved oxygen and pond turn over rate are monitored. IHOT standards are followed for: water quality, alarm systems, predator control measures (netting) to provide the necessary security for the cultured stock, fish loadings and densities. Settleable solids, unused feed, and feces are removed regularly to ensure proper cleanliness of rearing containers. All ponds are broom-cleaned as needed and pressure-washed between broods. Temperature and dissolved oxygen are monitored and recorded daily during fish-rearing. Temperatures during the rearing cycle range from a high of 65 to a low of 33 degrees F. Raceway vessels are cleaned on an as-needed basis.

Netting covers are placed over acclimation rearing ponds to minimize predation.

9.2.4 Indicate biweekly or monthly fish growth information (average program performance), including length, weight, and condition factor data collected during rearing, if available.

Rearing Period	Length (mm)	Weight (fpp)	Condition Factor
02/06	Na	858	Na
03/06	Na	567	Na
04/06	Na	195	Na
05/06	Na	99	Na
06/06	84	74	1.035

9.2.5 Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available.

Rearing Period	Length (mm)	Weight (fpp)	Condition Factor
02/06	Na	858	Na
03/06	Na	567	Na
04/06	Na	195	Na
05/06	Na	99	Na
06/06	84	74	1.035

9.2.6 Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*).

Rearing Period	Food Type	Application Schedule (# feedings/day)	Feeding Rate Range (%B.W./day)	Lbs. Fed per gpm of Inflow	Food Conversion During Period
2/16/06 – 4/17/2006	Ewos Micro#1 & 2	4-8	1.50-2.00	0.023	0.48
4/17/2006 – 5/29/2006	Ewos Pacific 1.2mm	4	1.5	0.026	0.55
5/29/2006 – 6/18/2006	Ewos Vita 1.5 mm w/boost	2	1.5	0.051	0.54

9.2.7 Fish health monitoring, disease treatment, and sanitation procedures.

Fish Health Monitoring	A fish health specialist inspects fish monthly and checks both healthy and if present symptomatic fish. Based visual detection of pathological problems, age of fish, and the history of the facility, the pathologist determines the appropriate tests. External signs such as lesions, discolorations, and fungal growths will lead to internal examinations of skin, gills, and organs. Kidney and spleen are checked for bacterial kidney disease (BKD). Blood is checked for signs of anemia or other pathogens. Additional tests for virus or parasites are done if warranted.
Disease Treatment	Appropriate therapeutic treatment will be prescribed to control and prevent further outbreaks. Dead fish are collected and disposed of at a landfill. Fish health and or treatment reports are kept on file.
Sanitation	All eggs brought to the facility are surface-disinfected with iodophor (per disease policy). All equipment (nets, tanks, boots, etc.) is disinfected with iodophor between different fish/egg lots. Different fish/egg lots are physically isolated from each other by separate ponds or incubation units. The intent of these activities is to prevent the horizontal spread of pathogens by splashing water. Tank trucks are disinfected between the hauling of adult and juvenile fish. Foot baths containing disinfectant are strategically located on the hatchery grounds to prevent spread of pathogens.

9.2.8 Smolt development indices (e.g. gill ATPase activity), if applicable.

Fall Chinook are released in May-June as sub-yearling smolts. Program goal has been to release fish when they reach 80 fpp. Along with size, appearance, and release time are used to indicate the readiness of the population for emigration.

ATPase data will be collected on fish released at Klickitat and Wahkiacus hatcheries to determine smoltification status.

9.2.9 Indicate the use of "natural" rearing methods as applied in the program.

None.

9.2.10 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to <u>listed</u> fish under propagation.

Listed fish are not under propagation.

Section 10. Release

10.1 Proposed fish release levels.

4.0 million fingerlings at 50-80 fish per pound (FPP).

10.2 Specific location(s) of proposed release(s).

Releases will be made from Klickitat Hatchery (RKm 68) and from the Wahkiacus Hatchery at RKm 27. Approximately 2 million fish will be released at each site.

10.3 Actual numbers and sizes of fish released by age class through the program.

Release Year	Fingerling Release		
	No.	Date (MM/DD)	Avg Size (fpp)
1996	4,380,000	05/16-06/08	64.0
1997	3,625,870	May	65.0
1998	4,387,480	05/21-05/31	71.0
1999	4,289,100	06/02-06/07	71.0
2000	3,972,500	05/15-05/22	55.0
2001	3,850,300	05/22-05/25	66.0
2002	3,968,900	06/03-06/07	65.0
2003	3,664,100/ 520,000	6/03-6/19/ 7/16-7/20	73.0 79.0
2004	2,590,650/ 1,635,000	6/14-18/ 7/6-13/	62.2 69.0
2005	2,150,500/ 2,397,800	6/12-16/ 6/19-21/	77.0 69.6

10.4 Actual dates of release and description of release protocols.

Fish will be allowed to migrate volitionally from the rearing ponds. Fish that do not migrate volitionally from the ponds will be seined and destroyed. Carcasses will be buried in an upland landfill.

10.5 Fish transportation procedures, if applicable.

Fingerlings are not transported.

10.6 Acclimation procedures (*methods applied and length of time*).

Chinook for this program will be reared on a combination of Klickitat River, adjacent spring water or well water for prior to release. Rearing on parent river water, or acclimation for several weeks to parent river water, is done to ensure strong homing to the release site, thus reducing the stray rate to natural populations.

10.7 Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.

1) 16.5% of all fish released will be adipose-clipped and coded-wire-tagged (CWT).

2) 100% of all Priest Rapid Hatchery origin fish (or fish from eggs) will be adipose-clipped until these fish/egg transfers are eliminated.

3) Klickitat River origin juveniles will be tagged with a blank cwt but not ad-clipped. This tagging approach will be maintained until the broodstock has been converted to 100% local origin**.**

10.8 Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

All NOR origin juveniles will be released. Eggs transferred from Priest Rapids are counted prior to transport so surplus has not been an issue in the past.

10.9 Fish health certification procedures applied pre-release.

Prior to release from Klickitat Hatchery, the population health and condition is established by the USFWS Fish Health Pathologist. This is commonly done 1-3 weeks pre-transfer and up to 6 weeks on systems with pathogen-free water and little or no history of disease. Prior to this examination, whenever abnormal behavior or mortality is observed, staff contacts the USFWS Fish Health Pathologist. The pathologist examines affected fish and recommends appropriate treatment. Reporting and control of selected fish pathogens are done in accordance with the Co-managers' Fish Disease Control Policy and USFWS guidelines.

10.10 Emergency release procedures in response to flooding or water system failure.

Emergency procedures and disposition of fish will adhere to the protocols and procedures set forth in approved operation plans. If the program is threatened by ecological or mechanical events, the Complex Manager will contact YN fish management. If an on-station emergency release is authorized, personnel will pull screens and sumps and fish will be force- released into the Klickitat River.

10.11 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases.

- Fish are reared to sufficient size (80 fpp) so that smoltification occurs simultaneously within almost the entire population. This will reduce retention in the streams after release.
- Fish that do not migrate volitionally from the ponds will be collected and destroyed, thus preventing the release of non-smolted fish.
- Rearing on natal river water or acclimation for several weeks to this river water is done to ensure strong homing to the hatchery, thus reducing adult stray rate to streams outside of the Klickitat River basin.
- The Yakama Nation transition plan calls for moving a portion of the program to lower Klickitat River acclimation sites in the future depending on funding.

This will reduce interactions with listed steelhead in the Klickitat River Subbasin.

Section 11. Monitoring and Evaluation of Performance Indicators

11.1.1 Describe plans and methods proposed to collect data necessary to respond to each "Performance Indicator" identified for the program.

*Harvest***:** Fisheries will be monitored by the co-managers to determine harvest rates and numbers in Columbia River and Klickitat River Subbasin fisheries. Ocean fisheries will be monitored by the WDFW and other entities by sampling fishing boats and fishers when they return to ports or to fish processing stations.

Smolt-to-adult Survival Rate: A portion of all releases will be marked with CWT and adipose fin-clipped. These tags will be recovered from fish caught in all fisheries, spawning ground surveys, hatchery returns, and from tags voluntarily submitted by the public.

Adult Straying: Regional M&E efforts will be used to track the number and capture location of fish originating from the Klickitat River.. Klickitat River fish will be tagged with a wire-tag so that they can be identified in fisheries, in spawning ground surveys, and at hatcheries.

*DNA (Broodstock composition)***:** A portion of the fin collected from adult fall Chinook at broodstock collection facilities will taken and the DNA analyzed. The adults will be given a unique numeric mark and then released to adult holding facilities. Only those adults identified as originating from the Klickitat River Subbasin will be used as broodstock.

*Juvenile Health Monitoring***.** Juvenile fish at Klickitat Hatchery are monitored on a routine basis by the hatchery staff to determine the condition of fry, fingerlings, and smolts. Samples will be taken by the USWS Fish Health pathologist to determine the health of fry, fingerling, and smolts prior to release. Sampling of fingerlings for tag retention and fin mark quality, prior to release, is conducted by YN marking program.

*Environmental Monitoring***.** Environmental monitoring is conducted at hatchery facilities to ensure that the facilities meet the requirements of the National Pollution Discharge Elimination System (NPDES) permit and is also used in managing fish health. On a short-term basis, environmental monitoring helps identify when changes to hatchery practices are required. The following parameters are currently monitored -

- Total Suspended Solids (TSS)
- Settleable Solids (SS)
- Water Temperature

11.1.2 Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.

BPA and Mitchell Act funding are expected to be sufficient to implement program and associated monitoring.

11.2 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from monitoring and evaluation activities.

- For fall Chinook, spawning/carcass surveys occur at a time when adult steelhead are not spawning.

- Any disturbance of adult or juvenile steelhead during spawning and carcass surveys is expected to be minimal because surveys are performed only once a week.

- Steelhead collected in broodstock collection facilities will be immediately returned with minimal handling to the river or stream..

Section 12. Research

12.1 Objective or purpose.

No research is proposed.

12.2 Cooperating and funding agencies.

NA

12.3 Principle investigator or project supervisor and staff.

NA

12.4 Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2.

NA

12.5 Techniques: include capture methods, drugs, samples collected, tags applied.

NA

12.6 Dates or time periods in which research activity occurs.

NA

12.7 Care and maintenance of live fish or eggs, holding duration, transport methods.

NA

12.8 Expected type and effects of take and potential for injury or mortality.

NA

12.9 Level of take of listed fish: number of range or fish handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and

the attached "take table" (Table 1).

NA

12.10 Alternative methods to achieve project objects.

NA

12.11 List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

NA

12.12 Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury or mortality to listed fish as a result of the proposed research activities.

NA

Section 13. Attachments and Citations

13.1 Attachments and Citations

Banks, J.L. 1994. Raceway Density and Water flow as Factors Affecting Spring Chinook Salmon (*Oncorhynchus tshawytscha*) during Rearing and after Release.Aquaculture, 119 (1994) 201-217. 54: pp. 137-147.

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Section 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

14.1 Certification Language and Signature of Responsible Party

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by_____________________________ Date:_____________

ADDENDUM A. PROGRAM EFFECTS ON OTHER (AQUATIC OR TERRESTRIAL) ESA-LISTED POPULATIONS

15.1) List all ESA permits or authorizations for USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species associated with the hatchery program.

No permits in place for this new program. They will be developed through consultation with appropriate agencies as facilities and programs are developed**.**

15.2) Describe USFWS ESA-listed, proposed, and candidate salmonid and non-salmonid species and habitat that may be affected by hatchery program.

Hatchery operations may impact USFWS listed Klickitat River bull Trout (*Salvelinus confluentus*). Bull trout are listed as Threatened by the USFWS. The USFWS has designated the West Fork Klickitat River and Klickitat River reaches adjacent to the Yakama Indian Reservation as Critical Habitat (Federal Register 2005). Stream habitat in the Klickitat River Basin has been impacted by human activities associated with agriculture, logging, recreation, and urban development.

Hatchery facilities are located both within and near the Klickitat River. Water for rearing anadromous fish at the Klickitat River hatchery is diverted from the river. New juvenile acclimation sites are being developed at Wahkiacus Hatchery that will disturb upland and riparian habitat near the stream channel. A diversion structure will also be built at this facility to provide water for acclimating hatchery smolts.

Other listed or candidate species that may be impacted by the construction and operation of the Wahkiacus Hatchery include:

Oregon Spotted Frog (*Rana pretiosa*)	Candidate
Bald Eagle (*Haliaeetus leucocephalus)*	Threatened
Northern Spotted Owl (*Strix occidentalis)*	Threatened

Possible impacts to these species from construction or operation of new facilities have not been quantified.

15.3) <u>Analyze effects.</u>

<u>Bull Trout</u>

Possible hatchery operational effects to listed bull trout in the Klickitat River are described below. The effects are expected to be on-going while the hatchery program remains in place.

Water diversion: Water is diverted from the Klickitat River for hatchery operations. This results in a decrease in the amount (0.25 miles) and quality of stream habitat at both the Wahkiacus and Klickitat River. The loss in habitat could result in a decrease in bull trout abundance. However, because bull trout are primarily found in the West Fork Klickitat River and tributaries higher in the Subbasin than the hatchery locations, impacts to bull trout are assumed minor.

Diversion Screens:

<u>Klickitat River Hatchery</u>: The Mitchell Act Intake and Screening Assessment (2002) identified design and alternatives needed to get existing diversion and screening structures in compliance with NOAA fish screening standards. From the assessment, YN has requested funding for future scoping, design, and construction work of a new intake system. Staff has not reported any bull trout entrained into hatchery facilities or impinged on screen surfaces.

<u>Wahkiacus Hatchery</u>: This facility will be equipped with screens that meet NMFS fry screening criteria.

Waste and Pollutants: Both facilities will operate under the "Upland Fin-Fish Hatching and Rearing" National Pollution Discharge Elimination System (NPDES) general permit which conducts effluent monitoring and reporting and operates within the limitations established in its permit administered by the Washington Department of Ecology (DOE). The limitations listed in the permit are assumed to be protective of water quality and therefore the hatchery waste water is likely to have little impact on bull trout.

Disease: Outbreaks in the hatcheries may cause significant adult, egg, or juvenile mortality. Over the years, advances in rearing densities, disease prevention and fish health monitoring have greatly improved the health of the programs at Klickitat Hatchery. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries (IHOT 1994) Chapter 5 have been instrumental in reducing disease outbreaks. Fish are planted and transferred after a fish health specialist has determined the populations' health. The level of <u>indirect take of bull trout from disease is unknown.</u>

Broodstock Collection: hatchery broodstock will be collected at traps located at Lyle Falls, Klickitat River Hatchery and Wahkiacus Hatchery. Although no bull trout have been collected in the past, the addition of new trapping facilities at Lyle falls and Wahkiacus Hatchery could result in the capture and handling of both bull trout juveniles and adults. Because the facilities will be designed to NMFS criteria, impacts to bull trout are expected to be minor. Any bull trout captured will be released unharmed to the stream.

Acclimation Facilities: New acclimation facilities are to be constructed at Wahkiacus Hatchery located at RKm 27. The diversion structure will be screened to meet NMFS criteria for fry. Impacts to bull trout from the diversion structure are expected to be minimal.

Release of Juveniles: The program will release 4.0 million fall Chinook smolts, at a size range of 80-100 mm, into the Klickitat River each year.. If it assumed that Chinook can consume fish that are up to 33% of their body length, there is the possibility that bull trout less than 36 mm may be susceptible to predation (See section 2). Because fall Chinook smolts will not be released in the primary bull trout spawning stream (West Fork Klickitat River) it is unlikely that the hatchery smolts will prey on, or compete with, listed bull trout.

Food: The carcasses of returning hatchery fall Chinook adults will increase stream productivity which should result in an increase in food abundance for bull trout. Additionally, fall Chinook juveniles (both hatchery and wild) could provide a food source for adult bull trout.

Monitoring and Evaluation: Smolt trapping may be used to determine if hatchery fall Chinook migrate quickly through the system after release. Some bull trout may be captured and handled at the trapping facilities; these fish will be released unharmed to the stream.

Oregon Spotted Frog

Neither hatchery operations nor proposed new facilities are likely to adversely impact this species. The only known population of Oregon Spotted Frog in the Klickitat River Subbasin is located in the Conboy Lake National Wildlife Refuge (NWR) managed by USFWS (Klickitat Subbasin Plan 2002). The refuge is located approximately 10 miles east of Trout Lake and 7 miles southwest of Glenwood in the Glenwood Valley/Camas Prairie area.

Bald Eagle

Bald eagles can be found throughout the year in the Klickitat River Subbasin. Because this species feeds on salmon, increased hatchery production should result in an increase in food for this species as a result of more adult fish returning to the Subbasin. Bald eagle surveys will be conducted prior to constructing any new facilities in the Subbasin.

Northern Spotted Owl

No impacts are expected to spotted owls because the existing facilities and the proposed facilities are not located in spotted owl habitat.

15.4) Actions taken to minimize potential effects.

Bull trout

Diversion Screens: All intake screens will be updated to meet NMFS screen criteria for fry.

Waste and Pollutants: All terms associated with the NPDES Permit will be implemented and followed.

Broodstock Collection: Any juvenile or adult bull trout captured during broodstock collection activities will be returned safely to the stream channel. Trapping facilities will be designed to meet NMFS standards.

Acclimation Facilities: These facilities will be sited to reduce impacts to riparian and stream habitats to the extent possible. The YN will coordinate the location and construction of this facility with USFWS staff to minimize or avoid impacts to all listed species.

Monitoring and Evaluation: Bull trout collected during juvenile trapping operations will be released unharmed to the stream.

Oregon Spotted Frog

Prior to constructing any facility, stream and riparian areas near proposed sites will be surveyed for the presence Oregon Spotted Frogs. If this species is found, the YN will coordinate with USFWS staff to develop mitigation and protection measures. This activity will be further in the EIS required for a Step 2 project.

Bald Eagle

Acclimation facilities will not be located near bald eagle nests.

Northern Spotted Owl

No activities are proposed that will impact this species because no facilities or activities are planned for areas inhabited by spotted owls or which are suitable spotted owl habitat.

15.5) References

IHOT (Integrated Hatchery Operations Team). 1995. Operation plans for anadromous fish production facilities in the Columbia River basin. Volume III-Washington. Annual Report 1995. Bonneville Power Administration, Portland Or. Project Number 92-043. 536 pp.

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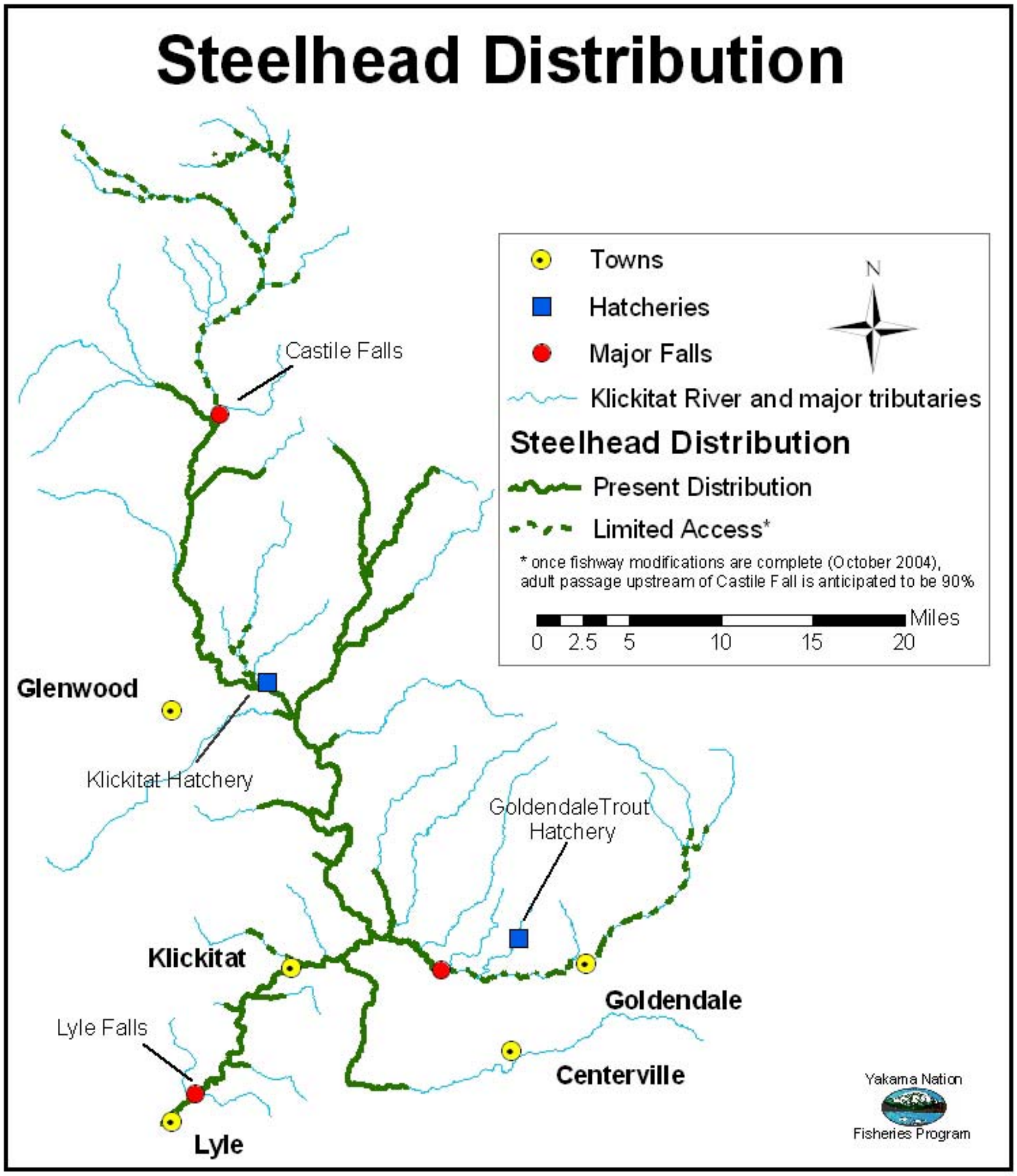
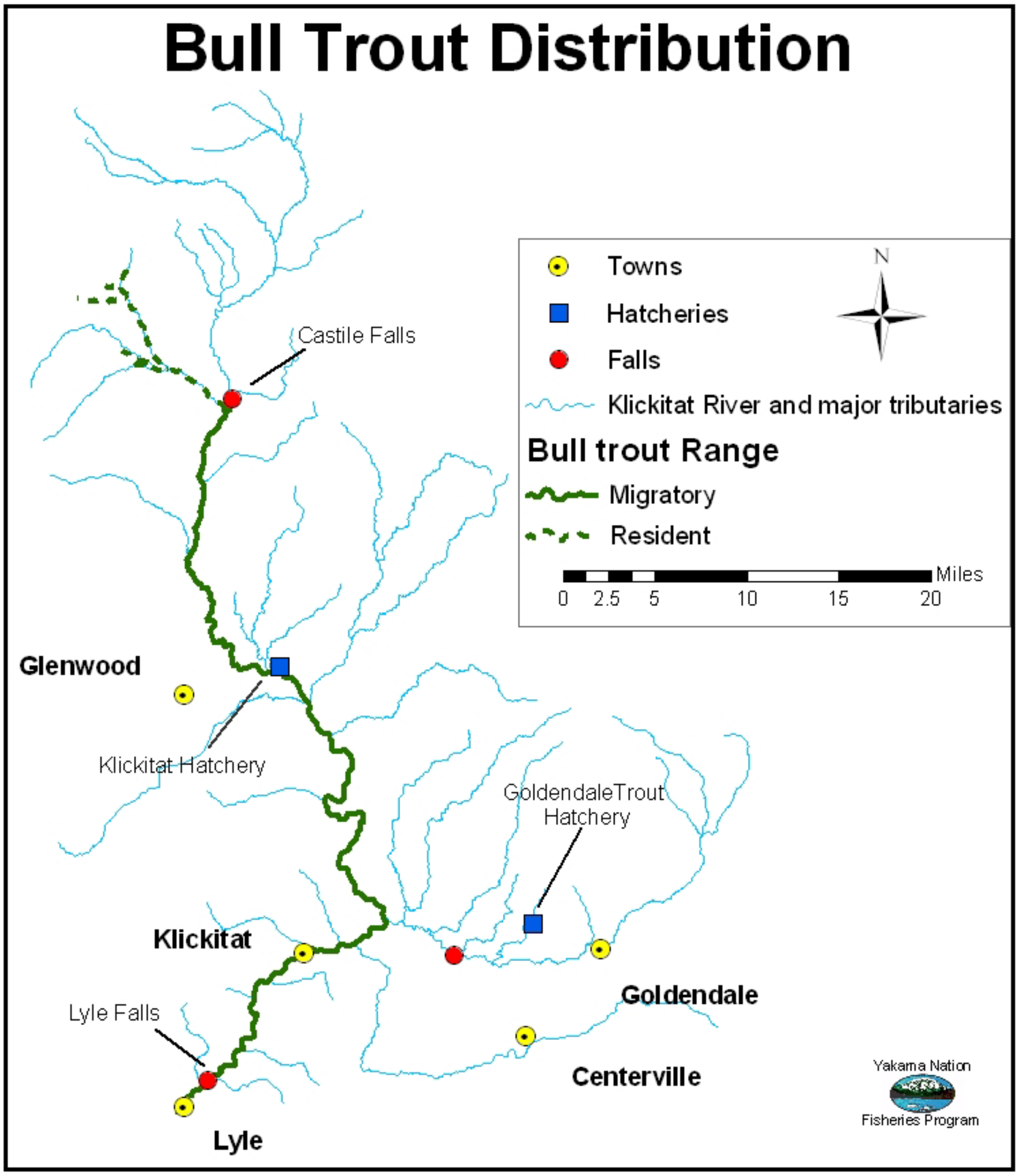
Yakama Nation 2008. Draft Klickitat River Anadromous Fisheries Master Plan, Yakima/Klickitat Fisheries Program. Toppenish,WA.

Appendix A- Steelhead and Bull Trout Distribution

Steelhead Distribution



Bull Trout


Bull Trout Distribution
Towns
Hatcheries
Falls
Klickitat River and major tributaries
Bull trout Range
Migratory
Resident
N
Miles
0 2.5 5 10 15 20
Castile Falls
Glenwood
Klickitat Hatchery
GoldendaleTrout
Hatchery
Klickitat
Lyle Falls
Goldendale
Centerville
Lyle
Yakama Nation
Fisheries Program

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Appendix C

EDT Overview, AHA Modeling Results, and Data Tables

Spring Chinook, Coho, Fall Chinook, and Steelhead

Klickitat River EDT modeling background

Overview:

The Ecosystem and Diagnostic Treatment (EDT) model was used to estimate the natural production potential of the habitat for species indigenous to the Klickitat River including spring Chinook and steelhead (Table 1). Several scenarios were included in the analysis to estimate historic, current, and future natural production of these species in the Klickitat Subbasin.

Historical habitat conditions are representative of the pre-Anglo settlement era or a time period when a relatively pristine environment existed in the Subbasin. Historical habitat conditions can also be viewed as an “upper bound” restoration potential of the Subbasin for naturally produced stocks. Population performance for current conditions represents the natural production potential for the current habitat state and should, therefore, predict equilibrium abundance similar to the observed.

Characterizing the future natural production potential as a function of the habitat improvements was projected for two separate time strata. The first time stratum represents the immediate and short-term future discounting restoration activities other than passage improvements completed at the Castile Falls complex in 2005. These passage improvements have recently opened up about 43 miles of previously un-occupied habitat to spring Chinook and steelhead. The scenario estimates the Subbasin’s natural production potential for spring Chinook and steelhead assuming the habitat above Castile falls has been sufficiently re-colonized.

The second time stratum includes habitat restoration activities across the watershed and within the spatial distribution of spring Chinook and steelhead. Abiotic and biotic attributes targeted for restoration consisted of level 2 attributes contributing to major limiting factors identified for individual geographic areas in the EDT strategic priority summary table for steelhead. Major limiting factors identified for Klickitat River steelhead can be viewed in Table 6-1 of the Klickitat Salmon Recovery Plan. The baseline modeling results for steelhead was chosen for identification of restoration activities due to their much larger spatial distribution that encompasses 100% of the spring Chinook distribution and because they are currently listed under the endangered species act, unlike Klickitat River spring Chinook. Although the restoration scenario is built around the limiting factors identified for steelhead, the approach is process based, focusing on restoring fluvial geomorphic processes affecting the functionality of the stream corridor and thus, anticipating substantial benefits to spring Chinook as well. For additional information pertaining to restoration strategies, see tables 7-4 through 7-9 in the Klickitat Salmon Recovery Plan.

A difficult task related to modeling a restoration scenario is quantifying the percent effectiveness of the action at both the tributary and stream reach scale. When using the EDT model, percent effectiveness is defined by the relative difference existing between the current and historic conditions of the watershed or any specified attribute. As an example, 100% effectiveness would fully restore a particular biotic or abiotic attribute to its historic condition whereas a 0% effectiveness rating would result in no restoration benefit, i.e. it would remain the same as it is defined for the current habitat conditions.

A. Habitat Potential

Table 1: Habitat Potential for Klickitat River Spring Chinook and Steelhead

Klickitat River Spring Chinook					
Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Klickitat Spring Chinook	Current Without harvest	41%	6.2	607	509
	Improved Castile Fishway Passage	97%	6.5	1,271	1,075
	Klickitat w/Restoration Actions	98%	7.7	1,360	1,183
	Historic Potential	99%	10.2	1,677	1,513
Klickitat River Steelhead					
Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Klickitat Steelhead	Current Without harvest	34%	4.2	1,621	1,233
	Improved Castile Fishway Passage	51%	4.5	2630	2,041
	Klickitat w/Restoration Actions	59%	5.3	2,823	2,286
	Historic Potential	75%	7.3	3,529	3,044

B. Harvest Rates for Klickitat River Anadromous Species

Table 2: Harvest Rates used for AHA models characterizing current programs and observed harvest rates by fishery

Current Programs				
Species	Fishery	Natural-Origin	Hatchery- Origin	Comments
Spring Chinook	Ocean	-	-	
	Zones 1-6	8.3%	8.3%	1996-2005 estimated mean- 2006 WDFW & ODFW Joint Staff Report
	Terminal	34.6%	34.6%	1996-2005 estimated harvest- Tribal Spring Chinook Database
Steelhead	Ocean	-	-	
	Zones 1-6	5.2%	10.2%	2005 Harvest Biop, Table 28[1/]
	Terminal	<15%	80.0%	YN Harvest Database[2/]
Fall Chinook	Ocean	38.3%	38.3%	1989-2005 Average harvest; YN Database[3/]
	Zones 1-5	17.9%	17.9%	
	Zone 6	20.3%	20.3%	
	Terminal	32.8%	32.8%	
Coho	Ocean	15.0%	53.7%	1987-2005 Average harvest; YN Database[4/]
	Zones 1-5	7.5%	27.6%	
	Zone 6	5.0%	5.0%	
	Terminal	83.1%	83.1%	

1/ Zones 1-6 incidental harvest/mortality rate of A-run steelhead from 1996-2003. Hatchery harvest assumes an additional 5% in Columbia mainstem sport fisheries.
2/ Tribal harvest wild fish has averaged about 22% plus an additional 5% hook and release mortality in terminal sport fishery.
3/ RMIS database queried for Marine and Zones 1-5 Harvest. 1992 not included due to insufficient tag recoveries in marine fisheries. Zone 6 and terminal derived from YN Database.
4/ RMIS database queried for Marine and Zones 1-5 harvest. 1989-1990, 1995-1996 not included due to insufficient tag recoveries in marine fisheries. Zone 6 and terminal derived from YN Database.

Table 3: Harvest Rates used for AHA models characterizing future programs and observed harvest rates by fishery

Future Programs					
Species	Fishery	Natural-Origin	Hatchery - Origin1	Hatchery - Origin2	Comments
Spring Chinook	Ocean	-	-	-	
	Zones 1-6	11.0%	11.0%	18.7%	Post 2005 Estimated Harvest zones 1-6[1/]
	Terminal	20.0%	20.0%	65.0%	Post 2005 Estimated terminal Harvest[2/]
Steelhead	Ocean	-	-	-	
	Zones 1-6	8.2%	13.2%		2005 Harvest BiOp, page 95[3/]
	Terminal	<15%	80.0%		Harvest rates not expected to change for indefinite future
Fall Chinook	Ocean	8.25%	38.3%		
	Zones 1-5		17.9%		Projected future harvest[4/]
	Zone 6	23.0%	20.3%		
	Terminal	17.2%	32.8%		
Coho	Ocean	15.0%	53.7%	-	
	Zones 1-5	7.5%	27.6%		Projected future harvest[4/]
	Zone 6	5.0%	5.0%		
	Terminal	83.1%	83.1%		

1/ Wild harvest based on *US v Oregon* schedule assuming a run size of 141,000 at Bonneville. Table 30, 2005 Biop. Hatchery harvest based 2001-2005 sport average plus estimated zone 6 hatchery harvest

2/ Estimated Tribal harvest of wild fish from 1996-2005 from YN Spring Chinook database. Hatchery harvest is the anticipated rate for combined fisheries under new program guidelines.

3/ Projected incidental harvest in Zones 1-6 post 2005. An additional 5% harvest of hatchery steelhead is expected in Columbia mainstem sport fishery.

4/ Maximum allowable harvest rates for marine and Zones 1-6 (2005-2007 Interim Management Agreement). Hatchery exploitation expected to remain the same as current in all fisheries.

C. Smolt-to-Adult Survival rates for Klickitat River Anadromous Species (HORs & NORs)

Table 4: Estimated smolt-to-adult return rates for CURRENT hatchery-origin returns (HORs) and natural-origin returns (NORs)

Current Programs			
Species	Origin	SAR	Comments
Spring Chinook	NORs	0.053	EDT Estimated NOR survival back to mouth
	HORs	0.002	Klickitat Hatchery Stock Average Survival before Exploitation
Steelhead	NORs	0.058	Estimated NOR survival back to mouth/1
	HORs	0.0265	Estimated Skamania Survival/2
Fall Chinook	NORs	0.017	EDT Estimate
	HORs	0.005	Klickitat hatchery releases average Survival before Expoitation/3
Coho	NORs	0.030	EDT Estimated NOR survival back to mouth
	$HORs_1$	0.003	Average survival for out-of-basin imports/4
	$HORs_2$	0.008	Average survival for in-basin releases5/

1/ Extrapolation from average Hood River NOR survival for brood years 1994-2002.
2/ Estimate based on run reconstructions for release years 1994-2002.
3/ Average Survival prior to exploitation. Based on available Brood years in HGMP
4/ Estimated average Survival of 2.5M smolts reared at Washougal Hatchery and scatter planted in Klickitat. Estimate based on available HGMP data.
5/ Estimated average Survival of 1.2M smolts reared and released from Klickitat hatchery. Estimate based on available HGMP data.

Table 5: Estimated smolt-to-adult return rates for Future hatchery-origin returns (HORs) and natural-origin returns (NORs)

Future Programs			
Species	Origin	SAR	Comments
Spring Chinook	NORs	0.053	EDT Estimated NOR survival back to mouth
	HORs	0.007	Projected Survival Prior to exploitation[/1]
Steelhead	NORs	0.058	Estimated NOR survival back to mouth[/2]
	HORs	0.018	Estimated NOR survival back to mouth[/3]
Fall Chinook	NORs	0.017	EDT Estimated NOR survival back to mouth
	$HORs_1$	0.008	Survival goal for initial future program
	$HORs_2$	0.010	Survival goal for longterm future program
Coho	NORs	0.030	EDT Estimated NOR survival back to mouth
	HORs	0.016	Survival goal for longterm future program

1/ Survival based on Yakima River CESRF hatchery recruitment rate of spring Chinook.
2/ Extrapolation from average Hood River NOR survival for brood years 1994-2002.
3/ Extrapolation from average Hood River NOR broodstock program brood years 1999-2002.

D. Hatchery Release Numbers

Table 6: Hatchery release numbers for current and future programs.

Current hatchery program release numbers			Future hatchery program release numbers	
Species	Hatchery Release 1	Hatchery Release 2	Hatchery Release 1	Hatchery Release 2
Spring Chinook	826,595		200,000	600,000
Steelhead	100,505		130,000	
Coho	2,467,656	1,238,563	1,000,000	
Fall Chinook	3,867,241		2,000,000	2,000,000

E. AHA Model results by Species

Table 7: AHA model runs for Klickitat River Spring Chinook current and proposed future programs

	Current conditions with segregated program			Future Integrated Program: With habitat above Castile Falls			Future Integrated Program: With habitat above Castile Falls & Restoration		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	2,866	217	713	2,560	209	657	2,854	259	748
HoS Total Escapement	1,545	268	506	3,284	321	877	3,578	371	968
HoS Effective Escapement	309	54	101						
Total Natural Escapement (NoS & All HoS)	4,276	499	1,219						
Total Harvest	8,074	1,377	2,612	12,868	1,963	3,911	12,998	1,985	3,951
Hatchery Broodstock	73	73	73	138		138	138		138
Surplus at Hatchery	1	0	0	6,463	653		6,463	653	1,682
Total Runsize	12,215	1,868	3,809	23,148	3,487	7,022	23,578	3,560	7,153

Table 8: AHA model runs for Klickitat River Steelhead current and proposed future programs

	Current Conditions W/Skamania hatchery plants			Future Integrated Program: With habitat above Castile Falls			Future Integrated Program: With habitat above Castile Falls & Restoration		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	2,866	217	713	7,221	1,065	2,158	8,116	1,236	2,460
HoS Total Escapement	1,545	268	506	275	47	90	292	50	95
HoS Effective Escapement	309	54	101	220	38	72	234	40	76
Total Natural Escapement (NoS & All HoS)	4,276	499	1,219	7,496	1,115	2,248	8,408	1,289	2,555
Total Harvest	8,074	1,377	2,612	10,105	1,704	3,214	10,458	1,766	3,332
Hatchery Broodstock	73	73	73	75	75	75	75	75	75
Surplus at Hatchery	1	0	0	1,103	192	362	1,168	204	383
Total Runsize	12,215	1,868	3,809	18,688	3,089	5,832	20,007	3,324	6,272

Table 9: AHA model runs for Klickitat River Fall Chinook Hatchery programs: Current and proposed future programs

	Current hatchery program performance			Projected future program performance: Initial Phase								
				Initial Phase						Long-term Phase		
	Out-of-Subbasin (4M)			Out-of-Subbasin (2M)			In-Subbasin			In-Subbasin (2M)		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	3,889	571	1,158	8	1	3	2,378	1	331	4,121	1	623
HoS Total Escapement	19,351	3,361	6,337	10,006	1,738	3,277	9,724	1,260	2,918	14,817	2,573	4,792
HoS Effective Escapement	9,676	1,681	3,168	5,003	869	1,638	4,862	630	1,459	11,854	2,058	3,834
Total Natural Escapement (NoS & All HoS)	23,240	3,965	7,495	10,014	1,739	3,279	11,942	1,261	3,249	18,938	2,574	5,415
Total Harvest	62,422	10,651	20,131	26,900	4,672	8,809	44,836	5,784	13,491	63,165	10,746	20,074
Hatchery Broodstock	2,251	2,251	2,251	1,164	1,164	1,164	1,165	703	1,045	1,165	968	1,147
Surplus at Hatchery	1	0	1	1	0	1	3,586	189	728	3,414	383	912
Total Runsize	85,663	14,617	27,626	36,916	6,412	12,089	61,528	7,938	18,514	86,683	14,746	27,548

Table 10: AHA model runs for Klickitat River Coho Hatchery programs: Current and proposed future programs

	Current performance of Hatchery programs						Future program performance goal		
	Current Conditions Hatch1			Current Conditions Hatch2			Future Hatchery program		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
NOR Escapement	226	27	63	1	0	0	427	2	79
HoS Total Escapement	2,739	475	897	1,794	311	587	1769	307	579
HoS Effective Escapement	2,191	380	717	1,435	249	470	1415	246	463
Total Natural Escapement (NoS & All HoS)	2,965	507	959	1,795	311	587	2196	322	658
							0	0	0
							0	0	0
Total Harvest	19,349	3,312	6,262	29,886	5,191	9,787	27115	11,055	14,018
							0	0	0
Hatchery Broodstock	2,345	2,345	2,345	1,177	1,177	1,177	952	952	952
Surplus at Hatchery	1	0	0	1	0	1	6442	593	1682
							0	0	0
Total Run size	22,313	3,819	7,222	31,682	5,503	10,375	36,705	12,922	17,310

Table 11: Klickitat NOR and HOR Spring Chinook spawner recruit data

Hatchery-origin Spawners

Brood Year	Spawners	Recruits	Recruits/Spawner
1990	177	334	1.88
1991	503	557	1.11
1992	620	1376	2.22
1993			
1994	534	371	0.69
1995	475	656	1.38
1996	582	2203	3.78
1997	663	621	0.94
1998	317	1825	5.76
1999	478	2460	5.15
2000	660	1615	2.45
2001	454	1803	3.97
Average	497	1256	2.67

Natural-Origin Spawners

Brood Year	Natural Spawners	Total Recruits	R:S
1990	231	55	0.24
1991	245	112	0.46
1992	322	686	2.13
1993	432	661	1.53
1994	105	201	1.91
1995	105	281	2.68
1996	290	1393	4.80
1997	599	525	0.88
1998	288	1872	6.50
1999	213	2352	11.04
2000	526	1298	2.47
Average	305	858	3.15

Table 12: Total Spring Chinook Run Size to Klickitat River Mouth

Year	Total	Hatchery	Wild
1977	904	763	141
1978	1,682	1,299	383
1979	3,772	3,700	72
1980	2,640	2,575	65
1981	2,721	2,388	333
1982	3,308	3,057	251
1983	2,590	2,353	237
1984	1,387	1,158	229
1985	942	414	528
1986	1,374	1,137	237
1987	1,793	1,345	448
1988	4,202	2,423	1,779
1989	5,762	5,166	596
1990	2,982	2,325	657
1991	1,723	1,250	473
1992	1,671	1,163	508
1993	3,746	3,020	726
1994	1,036	899	137
1995	967	842	125
1996	1,269	859	410
1997	1,913	1,114	799
1998	850	481	369
1999	1,288	1,021	267
2000	3,091	1,835	1,256
2001	1,546	1,023	523
2002	3,026	1,650	1,376
2003	4,507	2,280	2,227
2004	4,652	2,863	1,789
2005	1,361	1,120	241
2006	1,828	1,387	441
1992-2006 Avg	2183	1437	746
Proportion		65.8%	34.2%

Table 13: Survival of hatchery-origin spring Chinook by brood year (1990-2000)

Brood Year	Smolt to Adult Survival (%)
1990	0.08
1991	0.19
1992	0.29
1993	0.09
1994	0.01
1995	0.14
1996	0.54
1997	0.10
1998	0.62
1999	1.31
2000	0.32

Table 14: Total Harvest of Hatchery-origin Klickitat Spring Chinook

Return Year	Sport Harvest	Tribal Harvest	Total Catch (all ages)
1994	44	167	212
1995	11	125	137
1996	123	128	251
1997	162	116	279
1998	12	94	106
1999	105	103	208
2000	366	700	1,067
2001	136	226	362
2002	104	250	354
2003	425	503	928
2004	985	355	1,339
2005	189	349	538
2006	333	360	693

Table 15: Estimated harvest and run size information for Klickitat River coho (adults and jacks combined), 1987-2005

	Klickitat River[1]			L. Col. R. Harvest[3]	Marine[4] Harvest	Total Harvest
	Run	Harvest	Escape[2]			
1987	316	256	60	178	630	1,064
1988	12,386	9,619	2,767	8,666	20,292	38,577
1989	8,857	7,185	1,672	5,552		12,737
1990	3,055	2,478	577	1,131		3,609
1991	9,702	7,870	1,832	7,021	15,630	30,521
1992	534	433	101	232	1,505	2,170
1993	549	446	104	268	1,235	1,949
1994	3,882	3,149	733	1,451		4,600
1995	2,012	1,632	380	631		2,263
1996	896	698	198	231	3,254	4,183
1997	1,470	1,010	460	402	4,451	5,863
1998	3,379	2,846	533	546	5,578	8,970
1999	3,930	3,435	495	1,176	2,986	7,598
2000	5,808	4,871	938	1,855	3,211	9,937
2001	14,078	10,450	3,628	4,896	9,058	24,404
2002	9,901	8,701	1,200	3,340	7,220	19,262
2003	8,640	8,360	280	3,944	18,574	30,878
2004	5,959	5,817	143	1,816	13,695	21,328
2005	8,276	7,678	598	2,403	19,576	29,657
Avg[5]:	5,454	4,576	879	2,465	8,460	15,757

1. YN and WDFW database estimates.
2. Derived from redd count data assuming 2.5 fish per redd. For years when redd counts were unavailable, assumes average escapement-to-total-harvest ratio from years when redd counts were available. These data are likely underestimates, as water conditions often preclude accurate redd count estimates.
3. Derived from *U.S. v. Oregon* Technical Advisory Committee reports.
4. Derived from Regional Mark Information System (RMIS) recovery year data for marine and freshwater coded-wire tag (CWT) recoveries of coho released in the Klickitat River.
5. Klickitat River data are 1987-2005 averages. Averages for all other data are also for the period 1987-2005 and are exclusive of years when available CWT recovery data preclude an accurate estimate of marine harvest.

Table 16: Summary of Klickitat River fall Chinook harvest information

Run Year	Marine[1] Harvest	Col. R. Harvest[2]		Total Harvest[3]	Total Exploitation
		Zones 1-5	Zone 6		
1986		9,017	7,449	24,570	95.60%
1987		2,209	1,344	4,685	85.40%
1988		1,689	875	3,637	98.50%
1989	9,295	6,738	2,861	20,648	88.00%
1990	15,270	4,109	2,952	23,906	85.10%
1991	3,553	2,763	1,547	10,654	76.60%
1992		1,694	1,169	4,011	52.20%
1993	23,267	1,339	1,407	27,130	91.10%
1994	1,051	296	731	3,326	43.00%
1995	3,446	308	539	5,763	66.00%
1996	4,562	1,680	1,541	11,594	62.70%
1997	4,196	2,257	1,839	11,904	57.10%
1998	3,735	2,332	1,458	11,029	50.60%
1999	5,525	2,807	1,585	13,252	46.10%
2000	4,303	3,205	2,980	15,427	60.10%
2001	3,761	2,304	2,637	11,598	70.70%
2002	15,065	5,901	7,219	35,915	73.80%
2003	22,260	9,497	8,229	43,837	62.30%
2004	25,775	3,235	3,580	41,475	85.60%
2005	50,702	2,878	3,533	65,222	92.30%
Avg:		3,313	2,774	19,479	72.10%
Avg[5]:	12,235	3,228	2,790	22,042	69.40%

1 Derived from Regional Mark Information System (RMIS) recovery year data for marine and freshwater coded-wire tag (CWT) recoveries of fall Chinook released in the Klickitat River.
2 Derived from U.S. v. Oregon Technical Advisory Committee reports.
3 Includes Marine, Zones 1-6 and Terminal Fisheries
4 Data for 2002 to present are considered preliminary
5 Exclusive of years when available CWT recovery data preclude an accurate estimate of marine harvest.

Table 17: Klickitat River fall Chinook run size, terminal sport and tribal adult harvest, harvest rate and total escapement (1986-2005)

Year	Run Size to Klickitat Mouth	Klickitat River Harvest[3]		Total Terminal Harvest	Terminal Harvest Rate	Total Escapement
		Sport[4]	Tribal			
1986	8,766	7,598	506	8,104	92.4%	
1987	1,839	309	823	1,132	61.5%	
1988	1,073	449	624	1,073	100.0%	664
1989	4,346	1,114	640	1,754	40.4%	2,592
1990	5,468	668	906	1,574	28.8%	3,894
1991	5,737	431	2,360	2,791	48.7%	2,909
1992	4,583	282	866	1,148	25.0%	3,435
1993	3,586	513	605	1,118	31.2%	2,468
1994	5,377	741	508	1,249	23.2%	4,128
1995	4,213	993	477	1,470	34.9%	2,743
1996	10,168	2,029	1,782	3,811	37.5%	6,357
1997	11,940	1,995	1,617	3,612	30.3%	8,328
1998	13,566	1,212	2,292	3,504	25.8%	10,062
1999	17,906	1,790	1,545	3,335	18.6%	14,571
2000	14,428	1,584	3,355	4,939	34.2%	9,489
2001	7,327	1,456	1,441	2,897	39.5%	4,430
2002	19,465	1,710	6,020	7,730	39.7%	11,735
2003	28,899	1,927	1,925	3,852	13.3%	25,047
2004	15,068	2,411	6,474	8,885	59.0%	6,183
2005	12,887	1,980	6,129	8,109	62.9%	4,778
Avg:	9,832	1,560	2,045	3,604	42.4%	6,879

Appendix D

Monitoring the reproductive success of naturally spawning hatchery and natural spring Chinook salmon in the Wenatchee River by A.R. Murdoch, T.N. Pearsons, T.W. Maitland, M. Ford, and K. Williamson

Monitoring the reproductive success of naturally spawning hatchery and natural spring Chinook salmon in the Wenatchee River

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BPA Project No. 2003-039-00, Contract No. 00020391
Performance Period February 1, 2005-January 31, 2006

March 2006

Executive Summary

Salmon hatchery programs may unintentionally alter demographic characteristics relative to natural origin fish. Differences in demographic characteristics of adult hatchery and naturally produced fish could contribute to differences in reproductive success. Data from Wenatchee spring Chinook salmon was collected at Tumwater Dam, on spawning grounds, and at a hatchery to determine if differences exist. At Tumwater Dam, we found significant differences in run timing, age composition, sex ratios, and size at age between origin and age classes. Data collected during spawning at a hatchery showed that there were no significant differences in fecundity and egg weight between hatchery and naturally produced fish. Comparisons of data collected on carcasses recovered on the spawning grounds revealed no significant difference in egg retention between hatchery and natural origin fish. Preliminary results suggest that the hatchery program is altering certain demographic characteristics of adult spring Chinook salmon.

Hatcheries have been increasingly asked to contribute to conserving natural salmon populations, as well as to continue to produce fish to mitigate for lost harvest opportunities. A key biological uncertainty about the effects of hatchery production on natural populations is the degree to which hatchery produced fish can reproduce in the natural environment. In order to assess the impact (positive or negative) of supplementation of spring Chinook salmon in the Wenatchee River we are using a DNA-based pedigree analysis to (1) directly measure the relative reproductive success of hatchery and natural-origin spring Chinook salmon in the natural environment, (2) determine the degree to which any differences in reproductive success between hatchery and natural Chinook salmon can be explained by measurable biological characteristics such as run timing, morphology, and reproductive behavior, and (3) estimate the relative fitness of fish produced by hatchery-origin adults breeding in the natural environment and that have themselves returned to spawn.

Population genetic and preliminary parentage analyses have been carried out during the second year of monitoring reproductive success of naturally spawning hatchery and natural Spring Chinook salmon in the Wenatchee River. Eleven microsatellites were used to analyze population genetic structure for 2,969 adult Spring Chinook entering the Wenatchee R. drainage system during 2004. Significant genetic differentiation exists between adult hatchery and wild fish, and between wild adults returning to spawn in the Chiwawa River, Nason Creek, and the White River. Wild and hatchery samples have similar overall levels of genetic diversity, but patterns of diversity within each group differ. The wild samples are characterized by a slight heterozygote deficit (compared to random mating expectations), and generally have low levels of statistical associations among loci. In contrast, the hatchery samples are characterized by a slight heterozygote excess compared to random mating expectations, and have high levels of statistical associations among loci. These patterns probably reflect differences in effective population size or family structure between the two groups.

Preliminary testing of parentage assignment rates of 2004 Wenatchee R. Spring Chinook, performed separately for wild and hatchery fish, indicated assignment success rates

(proportion of simulations in which the most likely parent pair was the correct parent pair) were 97.8% and 82.7% for wild and hatchery fish, respectively. When a statistical criterion was used to limit incorrect assignments to no more than 5%, the total assignment rate dropped to 66.1% for the hatchery fish. These results reflect the higher degree of non-independence among loci observed for hatchery compared to wild fish and appear to be a consequence of the low numbers of spawners that produced the 2004 hatchery return. In order to predict the effects of adding additional loci to the analysis, a subset of several hundred of the 2004 adults were genotyped at an additional four loci (for a total of 15 loci). For the 2004 returns (~1800 hatchery origin fish), we predict ~90% of the time the parent pair with the highest likelihood would be the true parents using the 15 locus dataset, compared to 82.7% for the 11 locus set. Increasing the number of microsatellite loci genotyped will therefore be necessary to boost the power of parentage assignment in order to limit incorrect assignments to < 5% for hatchery fish. Even with the 11 locus dataset, we were able to make some inferences about fitness differences between hatchery and wild fish, however. For example, 2 and 3 year old hatchery males made up a large fraction of the male fish sampled at Tumwater Dam, but even after accounting for differences in assignment success, appeared to be very unsuccessful at producing progeny.

Spawning ground surveys in the upper Wenatchee River basin were used to evaluate spawning distribution and redd microhabitat characteristics of hatchery and naturally produced fish. In 2005, the composite population of spring Chinook redds were distributed similarly to that of years past. A total of 818 redds were found upstream of Tumwater Dam, of which the female origin was identified on 335 redds. Based on redd counts, the survival of spring Chinook from Tumwater Dam to the spawning grounds was estimated at 42.4%. After correction for carcass recovery bias, no differences were found in the estimated age composition or the proportion of hatchery and natural origin fish of the estimated spawning population compared to population sampled at Tumwater Dam. Hatchery origin fish tended to spawn in areas near the acclimation site or in relatively low elevation portions of tributaries. No difference in spawn timing of hatchery and natural origin spring Chinook was detected. Microhabitat variables were measured on 137 redds, which included 107 redds and 30 redds constructed by hatchery and natural origin females, respectively. No differences were found in any of the redd characteristics examined.

PIT tag detections were used to determine composition of adult hatchery and natural origin spring Chinook salmon on the spawning grounds. Snorkel surveys were used to determine the origin and abundance of precocious males on redds. The estimated number of precocious males that potentially contributed to natural spawning was 76 (13 hatchery, 50 natural, and 13 unknown origin). The low relative abundance of precocious males observed on the spawning grounds suggests that the majority of the precocious males observed at Tumwater Dam do not successfully migrate to the major spawning areas or die before spawning. The precocity rate for juveniles released from Chiwawa Ponds, that migrated downstream and survived to migrate upstream of Tumwater Dam was calculated as 0.13% in 2005. Assortative pairing analysis was limited in 2005 because hatchery and wild fish could not be distinguished because hatchery fish were not externally marked. No difference was detected in the mean fork length of males paired with either hatchery or natural origin females.

All data and analyses in this report should be considered preliminary until published in a scientific journal.

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General Introduction

This project will quantitatively evaluate the relative reproductive success of naturally spawning hatchery and natural origin spring Chinook salmon *Oncorhynchus tshawytscha* in the Wenatchee River. Hatcheries are one of the main tools that have been used to mitigate for salmon losses caused by the construction and operation of the Columbia River hydropower system. In addition to harvest augmentation, hatcheries have recently been used in attempts to protect stocks from extinction and to enhance natural production (supplementation). Surprisingly, little is known about how much the investment in hatcheries benefits or harms natural production. Recent technological advances in genetics have enabled the empirical monitoring of the reproductive success of hatchery and natural spring Chinook salmon using a DNA-based pedigree approach. Specifically, this project will (1) directly measure the relative reproductive success of hatchery and natural-origin Chinook salmon in both natural and hatchery settings, (2) determine the degree to which any differences in reproductive success between hatchery and natural Chinook salmon can be explained by measurable biological characteristics such as run timing or size, and (3) estimate the relative fitness of hatchery-lineage Chinook salmon after they have experienced an entire generation in the natural environment. This report contains results from the second year of work on this project. The results from the previous year of work were addressed in Murdoch et al. 2005. The project is intended to last until 2012 in order to evaluate two entire spring Chinook salmon generations.

This project is collaboration between NOAA-Fisheries (Northwest Fisheries Science Center) and the Washington Department of Fish and Wildlife. Results and progress are reported on jointly. This annual report is a joint authored report that has been split into four chapters in order to address important topics of the project. This project is an extension of the Chiwawa spring Chinook salmon supplementation program in the Wenatchee River operated by WDFW and funded by Chelan County Public utility District (CCPUD).

Description of Project Area

Located in north central Washington, the Wenatchee River subbasin drains a portion of the eastern slope on the Cascade Mountains. The watershed is approximately 3,550 km² with 383 rkm of major creeks and rivers (Andonaegui 2001). Originating from Lake Wenatchee, the Wenatchee River flows 86.9 kilometers to its confluence with the Columbia River (rkm 754) near the town of Wenatchee (Figure 1). High mountainous regions of the Cascade crest are encompassed in the watershed, with numerous tributaries draining subalpine regions included in the Alpine Lakes and Glacier Peak Wilderness areas (Andonaegui 2001).

Historical river discharge monitored by the United States Geological Survey (USGS gauging station number 12462500 at river km 9.4) reported a 41-year mean monthly summer low discharge of 23 m^3/s and a mean monthly spring peak discharge of 257 m^3/s. Of the total river discharge, the Little Wenatchee River (15%) and White River (25%) are the only tributaries that feed Lake Wenatchee (Mullan et al. 1992). Other primary tributaries of the Wenatchee River below the lake are Nason Creek (18%), Chiwawa River (15%) and Icicle Creek (20%; Mullan et al. 1992).

The Wenatchee River basin supports self-sustaining populations of spring and summer Chinook, steelhead *O. mykiss*, and sockeye salmon *O. nerka*. Spring Chinook spawning occurs primarily in the upper Wenatchee River basin (upstream of rkm 57.3), although limited spawning does occur annually in lower elevation tributaries (i.e., Icicle and Peshastin creeks). Spawning subpopulations have been documented in all major tributaries in the upper Wenatchee River basin including the upper Wenatchee, Chiwawa, Nason, White and Little Wenatchee (Mosey and Murphy 2002). Andonaegui (2001) reported natural fish passage barriers, in the form of waterfalls, limit access in the Chiwawa River (53.3 rkm), Nason Creek (27.0 rkm), White River (23.0 rkm), and the Little Wenatchee River (12.6 rkm). Despite these barriers, spawning typically ends before these barriers. Increases in stream gradient and substrate size may limit spawning below barriers (Andonaegui 2001).

History of Artificial Propagation

Over harvest in the lower Columbia River and destruction of spawning habitat had significantly reduced Chinook populations in the Wenatchee River Basin by the 1930's (Craig and Suomeia 1941). As part of the Grand Coulee Fish Maintenance Project (GCFMP) during 1939 – 1943, salmon and steelhead were trapped at Rock Island Dam and redistributed into the Wenatchee, Entiat and Methow rivers (Chapman et al. 1995). As a result, a mixed gene pool of fish originating from the Wenatchee, Entiat, Methow and Columbia River tributaries located upstream of the Grand Coulee Hydroelectric Project was created (Chapman et al. 1995). However, White River spring Chinook are genetically distinct from spring Chinook populations in the Chiwawa River and Nason Creek (Utter et al. 1995; Ford et al. 2001), and a low, but statistically significant level of genetic differentiation between Nason Creek and Chiwawa River populations was observed by Utter et al. (1995). Artificial propagation of spring Chinook in the Wenatchee Basin began in 1941. Leavenworth National Fish Hatchery (LNFH) released juvenile hatchery fish derived from broodstock collected at Rock Island Dam until 1944. Since 1948, hatchery spring Chinook have been released by the LNFH into Icicle Creek. Broodstock was collected in the Icicle River or transferred from other National Fish Hatcheries located in the lower Columbia River FH (Chapman et al. 1995). Currently, the spring Chinook program at LNFH released 1.6 million yearling smolts into the Icicle River, the purpose of which is harvest augmentation as part of the original mitigation for Grand Coulee Dam.

More recently, a supplementation program was initiated in 1989 on the Chiwawa River as part of the Rock Island Migration Agreement between Chelan County Public Utility District and the fishery management parties (RISPA 1989). The program is designed to mitigate for smolt mortality as a result of the operation of Rock Island Hydroelectric Project and has a production level goal of 672,000 yearling smolts. Currently, the program is operated under the Rock Island Habitat Conservation Plan and has established a goal for the program to increase the abundance of the naturally spawning population while maintaining the genetic integrity and long-term fitness of the stock (CCPUD 2002). However, low escapement to the Chiwawa River has limited smolt production and the mean number of smolts released since 1991 has been 101,843 (1989-2002 brood).

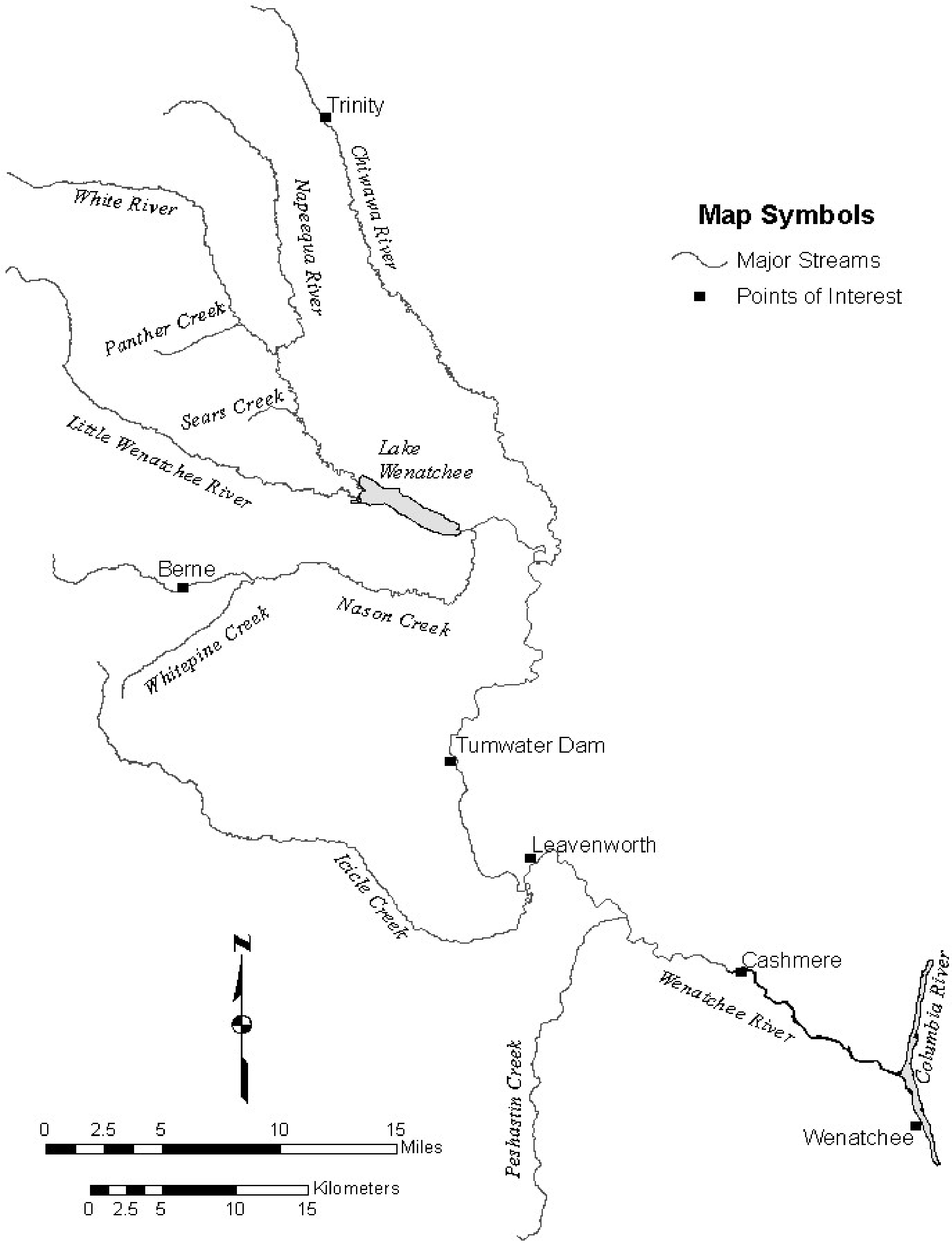

Figure 1. Map of Wenatchee River Basin and spring Chinook spawning tributaries.

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Chapter 1

A comparison of demographic variables of adult hatchery and natural origin spring Chinook in the Wenatchee River Basin

Abstract

Salmon hatchery programs may unintentionally alter demographic characteristics relative to natural origin fish. This is important because differences in demographic characteristics of adult hatchery and naturally produced fish could contribute to differences in reproductive success. Data from Wenatchee spring Chinook salmon were collected at Tumwater Dam, on spawning grounds, and at a hatchery to determine if differences exist. At Tumwater Dam, significant differences were found in the run timing, age composition, sex ratios, and size at age between origin and age classes of hatchery and natural origin spring Chinook. Data collected during spawning at a hatchery showed that there were no significant differences in fecundity and egg weight between hatchery and naturally produced fish. Comparisons of data collected on carcasses recovered on the spawning grounds revealed no significant difference in egg retention between hatchery and natural origin fish. Preliminary results suggest the hatchery program is altering certain demographic characteristics of the spring Chinook salmon population. It is unclear whether these differences are caused by genetic or environmental factors.

Introduction

Hatcheries can change the demographics of salmonid populations (Carmichael and Messmer 1995, Olson et al. 2004, Knudsen et al. in press). These changes may be caused by environmental factors associated with artificial culture or from genetic changes such as loss of within population genetic variation or domestication in the hatchery environment (Busack and Currens 1995). Quantifying differences in phenotypic traits of hatchery and natural origin salmonids can provide explanations for differences that may be observed through genetic analysis of relative reproductive success (Kostow et al. 2003; McLean et al. 2003). Resolving differences, or lack thereof, in phenotypic traits provides a better understanding of the potential causal factors that lead to differences in reproductive success.

This chapter examines some of the demographic variables that influence reproductive success. Specific objectives include examining differences in run timing, sex ratios, length, weight, fecundity, and egg weight. These variables may affect not only the survival of the spawners, but also the progeny. In addition, the proportion of eggs retained in post-spawned females was examined to assess any differences in egg deposition of hatchery and natural origin female spring Chinook.

Methods and Materials

Adult Trapping

Tumwater Dam is located on the Wenatchee River in Tumwater Canyon (rkm 43.7), approximately 30 km below historical spring Chinook spawning habitat (Figure 1). A fish ladder and trapping facility are located on the left bank of the dam. The trapping facility is comprised of four main parts. The first of these is the primary collection chamber (6.7 m × 2.3 m × 2.0 m; 30.8 m^3), which the fish enter after being diverted from the adult fish ladder. Two gravity fed upwells supply the chamber with a constant source of river water. Secondly, at the upstream end of the collection chamber fish must actively swim through a denile. At which time fish can be either diverted back to the river upstream of the dam, into a secondary collection chamber (3.4 m × 1.5 m × 3.4 m; 17.3 m^3), or if fish are to be sampled immediately into a tank (1.36 m^3) fed by a 5 hp pump. The secondary collection chamber is also fed river water through gravity fed upwells. Located at the bottom of the chamber is a large hopper (1.54 m^3) that is used to hoist fish from the collection chamber and also serves as an anesthetic tank. The final portion of the trapping facility is the recovery tank (1.72 m^3) and return flume, which is supplied with river water from another 5 hp pump. Revived fish are released upstream of the dam.

The fish trap is capable of operating either passively or actively. During periods when fish passage is low (< 20 fish/d) the trap is operated passively and the trap is checked periodically throughout each day as needed. When fish passage is high (> 20 fish/d) the trap is operated actively during the hours of daylight and passively during the night when fish are less likely to migrate. During active trapping, crews sort and divert spring Chinook into the secondary collection chamber using a series of pneumatic gates. Non-target species (i.e., summer Chinook, sockeye and steelhead), if not collected for hatchery broodstock, are immediately diverted back into the river upstream of the dam. The denile is shut down when between 10 and 15 adult spring Chinook have been diverted into the secondary collection chamber. At which time the water level in the secondary collection chamber is lowered and fish are crowded into the hopper. The hopper is hoisted to the work platform and a light concentration of MS-222 (14 ppm) is added before any fish are handled. Spring Chinook are transferred from the hopper into a sampling tank (0.38 m^3) containing a higher concentration of MS-222 (88 ppm). After sampling, fish are then placed either into a recovery tank or tanker truck if being collected as part of the hatchery broodstock. Fish placed in the recovery tank are allowed to fully recover before being released upstream.

Broodstock for the Chiwawa spring Chinook program were collected at Tumwater Dam (only hatchery fish with CWT) or a weir located on the Chiwawa River (both hatchery and natural origin fish) at river kilometer 1.5. The Chiwawa weir was operated 4 days per week and fish were collected weekly in proportion to the run. The broodstock goal for the Chiwawa program was 379 fish. All broodstock were transported to Eastbank FH and held on pathogen free well water until they were spawned.

Biological Sampling

Biological data were collected from all spring Chinook regardless of future disposition, hatchery broodstock or natural spawning. Each fish was identified to gender and scanned for passive integrated transponder (PIT) tags and coded wire tags (CWT). Fork and post orbital to hypural plate (POH) length were measured to the nearest cm and weight to the nearest 0.01 kg. Scale and genetic tissue samples (0.5 cm^2 caudal fin clip) were collected from every spring Chinook. All genetic samples were sent to the NOAA Fisheries, Northwest Fisheries Science Center for analysis (See Chapter 2). The presence or absence of the adipose fin was also recorded. Lastly, a PIT tag was inserted into the dorsal sinus cavity on the left side of the body. In some cases a fish that had been previously sampled (i.e, fallback) was encountered. These fish were confirmed by the presence of caudal fin clips. PIT tag numbers of all fallbacks were recorded and fish were released upstream. All PIT tag data were uploaded to the PTAGIS database on a weekly basis.

Similar biological data were collected on hatchery and naturally produced fish used for hatchery brood stock (i.e., sex, spawn date, fork and POH length, and scales). The fecundity of each female was determined by using an optical egg counter. Before eggs from individual females are counted, the optical counter was calibrated with a known number of eggs. A sample of 100 eggs from each female was also weighed (to the nearest 0.1 g). The mean egg weight of each female was calculated by dividing the sample weight by the number of eggs.

Data Analysis

Non-parametric tests were primarily used to analyze data because most variables were not normally distributed, even after various transformations were applied ($P > 0.05$, Shapiro-Wilk Normality Test). Run timing of hatchery and natural origin fish by age class were compared using a Kruskal-Wallis analysis of variance (KW). Age composition and sex ratios of hatchery and naturally produced adult spring Chinook were compared with a Chi-square test using a Yates (1934) correction for continuity to prevent inflating the probability of committing a Type I error.

Body length (POH) and weight of hatchery and wild fish by age class and sex were compared using a KW test. Due to small sample sizes of age 3 and 5 fish, only age-4 fish, the dominant age class sampled at Tumwater Dam in 2004 and 2005, were used in the analysis of length (POH) and weight at age. Only natural origin fish collected as broodstock from the Chiwawa weir or sampled during spawning ground surveys in the Chiwawa River were included in the analysis. Comparisons of hatchery fish were limited to only natural origin Chiwawa River spring Chinook because hatchery fish are of Chiwawa River origin. Fecundity and egg weight of hatchery and naturally produced females of the same age were compared using a KW test. A linear regression was performed using fish size (FL) and fecundity for both, hatchery and wild broodstock. The slopes of the regression models were compared using homogeneity of slopes test and analysis of covariance (ANCOVA). Using the regression models, the estimated fecundity for all females examined for egg retention was calculated and used to determine the proportion of eggs retained. The proportion of eggs retained in hatchery and wild carcasses found on the spawning grounds was compared using a KW test.

Results and Discussion

Trap Operation

The trap was operated between 1 May and 11 August 2005. The trap operated passively from 1 May to 23 May due to low fish passage. During this time period, personnel checked the trap and sampled fish several times daily. Active trapping occurred during the day between 24 May and 11 August, and was passively operated only during night when fish passage was low. Previous trap modifications performed as expected and no mechanical or technical failures occurred throughout the entire time period. No mortality occurred during the trapping period.

A total of 3,827 spring Chinook adults and jacks and 297 precocious males (age-2) were counted at Tumwater Dam, including 3 spring Chinook adults that were counted on videotapes after trapping had ended (Figure 1). Origins of fish were determined by CWT or scales collected at Tumwater Dam, carcasses from the spawning grounds, or broodstock spawned at the hatchery. Of these fish, genetic tissue samples were collected from 3,219 hatchery adults, 570 natural adults, 34 unknown origin, and 295 hatchery precocious males (99.9% of all spring Chinook at Tumwater Dam). Naturally produced spring Chinook were observed (captured or video) at Tumwater Dam between 14 May and 29 August (108 days). Hatchery spring Chinook were captured at Tumwater Dam between 17 May and 09 August (85 days). In addition, hatchery Chinook (94.6%; N=281 adipose clipped and 5.4%; N=16 adipose present) were observed from 30 May to 08 August (Figure 1, Appendix A). No naturally produced precocious males were observed during trapping.

Run timing

Differences in run timing were detected between age classes ($P < 0.001$). Older aged spring Chinook migrate earlier than younger spring Chinook (Table 1). However, within each age class no differences were detected in the passage timing at Tumwater Dam between hatchery and natural origin age-3 ($P = 0.63$) or age-5 ($P = 0.78$) spring Chinook (Figure 2). However, natural origin age-4 fish had significantly later run timing than age-4 hatchery origin fish (Table 2, $P < 0.001$). A comparison of run timing by origin and sex of age-4 spring Chinook detected differences for both male and female spring Chinook ($P < 0.001$). Run timing differences in different ages observed in the Wenatchee Basin are similar to those found in the Yakima Basin. Knudsen et al. (In press) reported that adults had a 19-20 day earlier run timing than jacks. Furthermore, the run timing of natural origin adult Yakima spring Chinook was not significantly different than adult hatchery origin fish.

Figure 1. Run Timing of adult hatchery and naturally produced spring Chinook and Chinook sampled at Tumwater Dam in 2005.

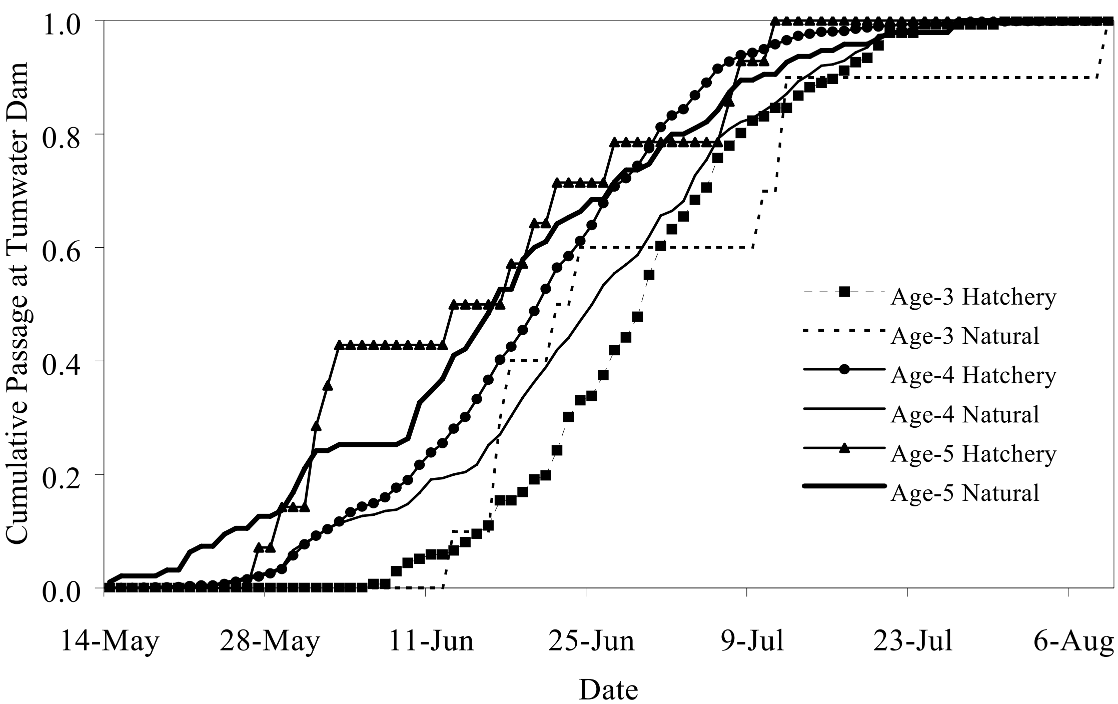

Figure 2. Cumulative passage timing of spring Chinook at Tumwater Dam in 2005.

Table 1. Cumulative passage dates of Wenatchee River spring Chinook sampled at Tumwater Dam in 2004 and 2005.

Origin/Age	Cumulative Run Timing		
	10%	50%	90%
		2004	
Hatchery (All[1])	10-Jun	25-Jun	08-Jul
Age-2	26-Jun	13-Jul	21-Jul
Age-3	13-Jun	27-Jun	09-Jul
Age-4	05-Jun	24-Jun	07-Jul
Age-5	08-Jun	12-Jun	04-Jul
Natural (All)	04-Jun	20-Jun	06-Jul
Age-3	12-Jun	27-Jun	14-Jul
Age-4	03-Jun	20-Jun	05-Jul
Age-5	05-Jun	17-Jun	12-Jul
		2005	

Hatchery (All[1])	02-Jun	21-Jun	06-Jul
Age-2	23-Jun	13-Jul	26-Jul
Age-3	16-Jun	30-Jun	17-Jul
Age-4	02-Jun	21-Jun	06-Jul
Age-5	29-May	13-Jun	08-Jul
Natural (All)	01-Jun	24-Jun	14-Jul
Age-3	13-Jun	22-Jun	12-Jul
Age-4	02-Jun	26-Jun	14-Jul
Age-5	25-May	17-Jun	10-Jul

[1] For comparison age-2 hatchery fish were not included

Table 2. Summary statistics of run timing for hatchery and natural origin spring Chinook at Tumwater Dam in 2004 and 2005 (H = hatchery; N = natural).

Age/Origin	*N*	Mean	Median	Minimum	Maximum	SD (days)
			2004			
2 H	635	Jul 11	Jul 13	Jun 10	Aug 03	9
3 H	826	Jun 26	Jun 27	Jun 04	Jul 26	10
3 N	31	Jun 27	Jun 27	Jun 06	Jul 21	12
4 H	453	Jun 22	Jun 24	May 20	Aug 06	13
4 N	845	Jun 19	Jun 20	May 18	Jul 27	13
5 H	6	Jun 16	Jun 17	Jun 08	Jul 04	10
5 N	12	Jun 19	Jun 17	Jun 03	Jul 13	13
			2005			
2 H	297	Jul 11	Jul 13	May 30	Aug 8	13
3 H	136	Jun 29	Jun 30	Jun 06	Jul 31	11
3 N	10	Jun 30	Jun 23	Jun 13	Jul 21	18

4 H	2,992	Jun 20	Jun 21	May 17	Jul 21	13
4 N	465	Jun 25	Jun 26	May 18	Jul 21	15
5 H	14	Jun 15	Jun 15	May 27	Jul 12	16
5 N	95	Jun 17	Jun 17	May 14	Jul 28	17

Age Composition

Ages were determined through scale samples for 3,142 and 570 hatchery and natural spring Chinook, respectively (Table 3). All 297 hatchery precocious males were scale sampled and determined to be age-2 fish, but were not included in the analysis because the number of natural origin age-2 could not be determined. A significant difference was found in the age composition of hatchery and natural origin fish ($\chi^2 = 3142$, df = 2, $P < 0.001$). Differences in age composition between hatchery and natural origin fish was attributed to the variation in the number of hatchery fish released (range 47,104 – 377,544).

Because of these differences, a comparison of age composition by brood year would demonstrate any real differences in age composition that may be attributed to the hatchery program. Age and sex of the 2000 brood Wenatchee spring Chinook was determined at Tumwater Dam between 2004 and 2005 as part of this study. The number of age-3 spring Chinook in 2003 was determined from videotapes and trapping records from Tumwater Dam (WDFW, unpublished data). Significant differences were detected between hatchery and natural origin fish ($\chi^2 = 26.5$, df = 2, $P < 0.001$). A greater proportion of natural origin fish returned at age-5 than hatchery fish (Table 4). Mean age-at-maturation was also earlier in the hatchery origin spring chinook salmon (shifting to age 3) than natural origin fish in the Yakima River (Knudsen et al. in press).

Table 3. Age composition of Wenatchee River spring Chinook sampled at Tumwater Dam in 2004 and 2005 (Age-2 fish not included).

Origin	Total Age			*N*
	3	4	5	
		2004		
Hatchery	64.1%	35.4%	0.5%	1,273
Natural	3.5%	95.2%	1.3%	888
All	39.2%	60.0%	0.8%	2,161
		2005		
Hatchery	4.33%	95.22%	0.45%	3,142
Natural	1.75%	81.58%	16.67%	570
All	3.93%	93.13%	2.94%	3,712

Table 4. Age composition of the 2000 brood Wenatchee River spring Chinook sampled at Tumwater Dam in between 2003 and 2005.

Origin	Total Age 3	Total Age 4	Total Age 5	*N*
Hatchery	7.09%	90.16%	2.76%	508
Natural	7.11%	83.50%	9.39%	1,012
All	7.11%	85.72%	7.17%	1,520

<u>*Sex Ratio*</u>

Sex determination at Tumwater Dam was based on external morphological characteristics early in the year without secondary sexual characteristics and may not be accurate. A comparison of the sex determined at Tumwater Dam to those fish subsequently recovered on the spawning grounds and during hatchery spawning found that sex determination was correct 86.1 % for female and 80.0% for males. After correction, the male to female ratio of the natural and hatchery fish was 1.0 to 1.0 and 0.78 to 1.0, respectively (Table 5). The overall male to female ratio for the spawning population upstream of Tumwater Dam (broodstock not included) was 0.8 to 1.0. In the future, an ultrasound unit may be used to visualize gonad morphology. This will eliminate error associated with determining gender based solely on external morphological characteristics.

Age-4 hatchery fish had significantly lower proportion of males than age-4 natural origin fish ($\chi^2 = 50.52$, $P < 0.001$). No difference was detected in the sex ratio of age-5 hatchery and natural origin fish ($\chi^2 = 0.14$, $P = 0.71$). A lower proportion of older aged males suggest that hatchery males may mature at an earlier age than natural origin males. For example, the number of hatchery age-3 males sampled at Tumwater Dam was much greater than natural origin fish. As stated previously, because the number of hatchery fish released was not constant, analysis of sex ratios should be conducted when all age classes from each brood year has been sampled at Tumwater Dam.

Comparisons between gender and origin of the 2000 brood Wenatchee spring Chinook were based on the number of male and female spring Chinook, corrected based on carcass recovery data, sampled at Tumwater Dam between 2003 and 2005. Based on carcass recovery data in 2003, all age-3 fish were determined to be males (WDFW, unpublished data). A significantly greater proportion of the 2000 brood hatchery fish return as females compared to natural origin fish (Table 6; $\chi^2 = 38.94$, df = 1, $P<0.001$). These results are also consistent with differences detected within the run year (e.g., 2005). The overall male to female ratio of hatchery and natural origin fish was 0.42:1 and 0.95:1, respectively. A higher proportion of hatchery females may be attributed to differences in the proportion of males that mature as age-2 (i.e., precocious males). If a greater proportion of hatchery males were sexually mature at age-2, a relatively lower proportion of the returning hatchery adults would be males compared to natural origin fish. These results support the lack of natural origin age-2 fish observed at Tumwater Dam and on the spawning grounds (Chapter 4) in both 2004 and 2005. Sex composition in natural and hatchery origin spring chinook salmon differed in 3 of 4 brood years in the Yakima Basin (Knudsen et al. in press). This difference was largely attributed to an increase in age 3 jacks which increased from 38 to 49 percent over time.

Table 5. The estimated number of male and female spring Chinook counted at Tumwater Dam and the corrected number based on carcass recoveries in 2004 and 2005.

Age	Origin	Sex	Tumwater Dam	Corrected Number
		2004		
3	Hatchery	Male	821	823
		Female	5	3
	Natural	Male	31	31
		Female	0	0
	Unknown	Male	1	1
4	Hatchery	Male	115	107
		Female	343	351
	Natural	Male	438	374
		Female	407	471
	Unknown	Male	1	1
	Unknown	Female	0	0
5	Hatchery	Male	2	2
		Female	4	4
	Natural	Male	5	5
		Female	7	7
	Unknown	Male	0	0

	Unknown	Female	0	0
Unknown	Hatchery	Male	27	22
		Female	11	16
Unknown	Unknown	Male	17	14
		Female	13	16
		2005		
3	Hatchery	Male	136	136
		Female	-	-
	Natural	Male	10	10
		Female	-	-
	Unknown	Male	1	1
4	Hatchery	Male	1,243	1,237
		Female	1,749	1,755
	Natural	Male	257	235
		Female	208	230
	Unknown	Female	1	1
5	Hatchery	Male	6	6
		Female	8	8
	Natural	Male	51	46
		Female	44	49
Unknown	Hatchery	Male	29	30
		Female	49	48
Unknown	Unknown	Male	15	14
		Female	17	18

Table 6. Summary of the 2000 brood hatchery and natural origin Spring Chinook by sex and age observed at Tumwater Dam between 2003 and 2005.

Age	Male		Female	
	Hatchery	Natural	Hatchery	Natural
3	7.1%	7.1%	0.0%	0.0%
4	21.0%	37.0%	69.1%	46.5%
5	1.2%	4.6%	1.6%	4.8%

Size-at-Age

In 2005, no difference in POH was detected between age-4 natural origin male and female Chiwawa spring Chinook (P = 1.0). However, age-4 hatchery male spring Chinook were significantly larger than hatchery female and both natural male and female spring Chinook (Table 7, $P < 0.05$). A comparison of age-3 spring Chinook in 2004 (i.e., same brood year 2001) also found differences consistent with age-4 fish (two sample t-test, t = -2.09, $P < 0.04$). When compared to spring Chinook sampled in 2004, the only difference detected between similar groups (sex and origin) was hatchery males (P = 0.05; Figure 3). Age-4 hatchery males were significantly larger in 2005 than 2004. Similarly, the only within or between year differences in weight between hatchery and natural origin Chiwawa spring Chinook were natural origin males in 2005 ($P < 0.001$). Mean lengths and body weights of 3, 4, and 5, year old hatchery spring chinook salmon in the Yakima Basin were less than those of natural origin fish of the same age (Knudsen et al. in press).

Table 7. Mean fork length (SD) and weight (SD) at age for Wenatchee River spring Chinook sampled at Tumwater Dam in 2004 and 2005.

Origin/Year	Sex	*N*	Age-3	*N*	Age-4	*N*	Age-5
			Fork length (cm)				
Hatchery 2004	Male	821	52.9 (5.9)	115	80.2 (6.6)	2	98.0 (1.4)
	Female	5	62.2 (4.9)	343	79.6 (4.5)	4	82.8 (8.4)
	All	826	53.0 (6.0)	458	79.7 (5.1)	6	87.8 (10.3)
Natural 2004	Male	31	50.7 (5.4)	438	78.5 (6.5)	5	91.6 (4.8)
	Female	0		407	77.9 (4.0)	7	91.3 (5.7)
	All	31	50.7 (5.4)	845	78.3 (5.5)	12	91.4 (5.1)
Hatchery 2005	Male	136	54.8 (4.5)	1,188	82.5 (5.9)	6	90.2 (6.8)
	Female	0		1,804	79.3 (4.0)	8	88.1 (6.4)
	All	136	54.8 (4.5)	2,992	80.6 (5.1)	14	89.0 (6.4)
Natural 2005	Male	10	52.0 (3.7)	231	78.4 (6.6)	44	96.2 (6.5)
	Female	0		234	79.3 (4.8)	51	91.7 (4.1)
	All	10	52.0 (3.7)	465	78.8 (5.8)	95	93.8 (5.7)

			Weight (g)				
Hatchery 2004	Male	821	1.76 (0.66)	115	5.49 (1.40)	2	9.10 (0.42)
	Female	5	2.85 (0.75)	343	5.51 (0.98)	4	6.15 (1.84)
	All	826	1.77 (0.66)	458	5.50 (1.10)	6	7.13 (2.10)
Natural 2004	Male	31	1.52 (0.56)	438	5.33 (1.27)	5	7.86 (1.01)
	Female	0		407	5.29 (0.81)	7	8.22 (1.77)
	All	31	1.52 (0.56)	845	5.31 (1.07)	12	8.08 (1.46)
Hatchery 2005	Male	136	1.84 (0.46)	1,188	6.08 (1.31)	6	8.10 (2.20)
	Female	0		1,804	5.42 (0.87)	8	7.23 (1.41)
	All	136	1.84 (0.46)	2,992	5.68 (1.11)	14	7.60 (1.77)
Natural 2005	Male	10	1.60 (0.29)	231	5.21 (1.28)	44	9.46 (2.21)
	Female	0		234	5.38 (0.96)	51	8.13 (1.31)
	All	10	1.60 (0.29)	465	5.30 (1.13)	95	8.75 (1.90)

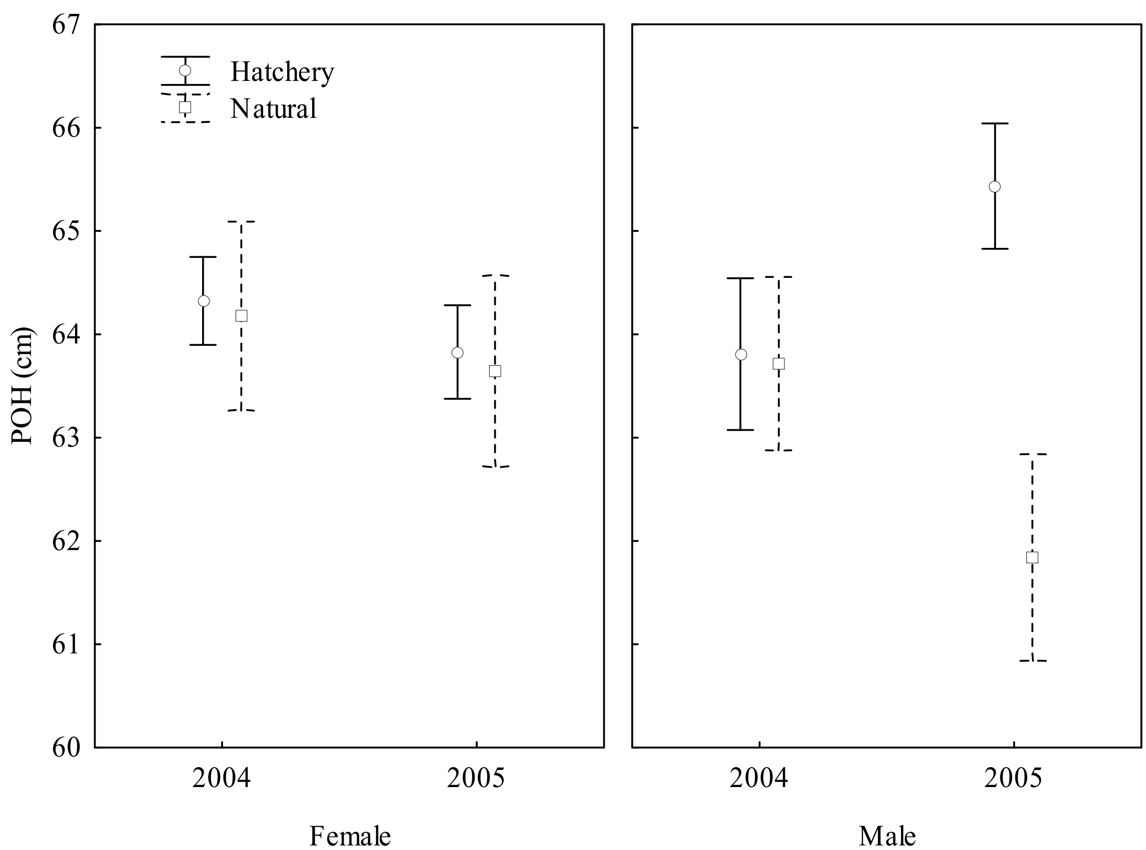

Figure 3. Mean post-orbital to hypural plate length of age-4 Chiwawa spring Chinook sampled on the spawning grounds and as broodstock in 2004 and 2005. Vertical bars denote 95% confidence intervals.

Fecundity and Egg Weight

A total of 283 spring Chinook were collected and held at Eastbank Fish Hatchery for broodstock in 2005. Age and origin was determined through scale analysis and CWT decoding for 183 and 99 hatchery and wild fish, respectively (Table 8). Scales from one fish were unreadable. Fecundity was determined for 89 hatchery and 37 naturally produced age-4 and age-5 female spring Chinook (Table 9). The mean (standard deviation, SD) fecundity of the hatchery and naturally produced females was 4,211 (721) and 4,279 (1,033), respectively. Mean egg weight (SD) of the hatchery fish was 0.23 (0.03) g and 0.23 (0.04) g for the naturally produced fish. No difference was found between the mean fecundity ($P = 0.07$) and egg weight ($P = 0.33$) of hatchery and naturally produced age-4 fish in 2005.

No difference in the slope of the fecundity regression line was detected between years ($P = 0.82$), origin ($P = 0.71$), or the interaction term year x origin ($P = 0.20$). Subsequently, results of the ANCOVA using the same data to examine differences in the intercept of the regression lines detected no difference in origin ($P = 0.57$), but differences were detected between years ($P < 0.001$). These results suggest that age-4 hatchery and natural Chiwawa spring Chinook have similar fecundity to length relationships within a given year, but both hatchery and natural fish may differ similarly between years (Figure 4). Comparisons between years (2004 and 2005) found significant differences in both fecundity ($P < 0.001$) and egg weight ($P < 0.001$), but no difference was detected among hatchery and natural origin spring Chinook within the same year.

Table 8. Age composition of Chiwawa spring Chinook hatchery broodstock at Eastbank Fish Hatchery in 2004 and 2005.

Origin	Total Age			*N*
	3	4	5	
		2004		
Hatchery	37.3%	62.7%	0.0%	193
Natural	4.3%	92.5%	3.2%	93
All	26.6%	72.4%	1.0%	286
		2005		
Hatchery	4.4%	94.5%	1.1%	183
Natural	1.0%	84.9%	14.1%	99
All	3.2%	91.1%	5.7%	282

Table 9. Summary statistics for Chiwawa spring Chinook broodstock fecundity and egg weights in 2004 and 2005.

Origin	Age	Fecundity	Egg Weight

		Mean	SD	*N*	Mean	SD	*N*
				2004			
Hatchery	4	4,676	901	83	0.216	0.029	89
Natural	4	4,833	747	37	0.211	0.029	37
Natural	5	4,203	-	1	0.242	-	1
				2005			
Hatchery	4	4,211	721	89	0.228	0.034	91
Natural	4	3,961	637	30	0.225	0.040	31
Natural	5	5,642	1,327	7	0.260	0.039	6

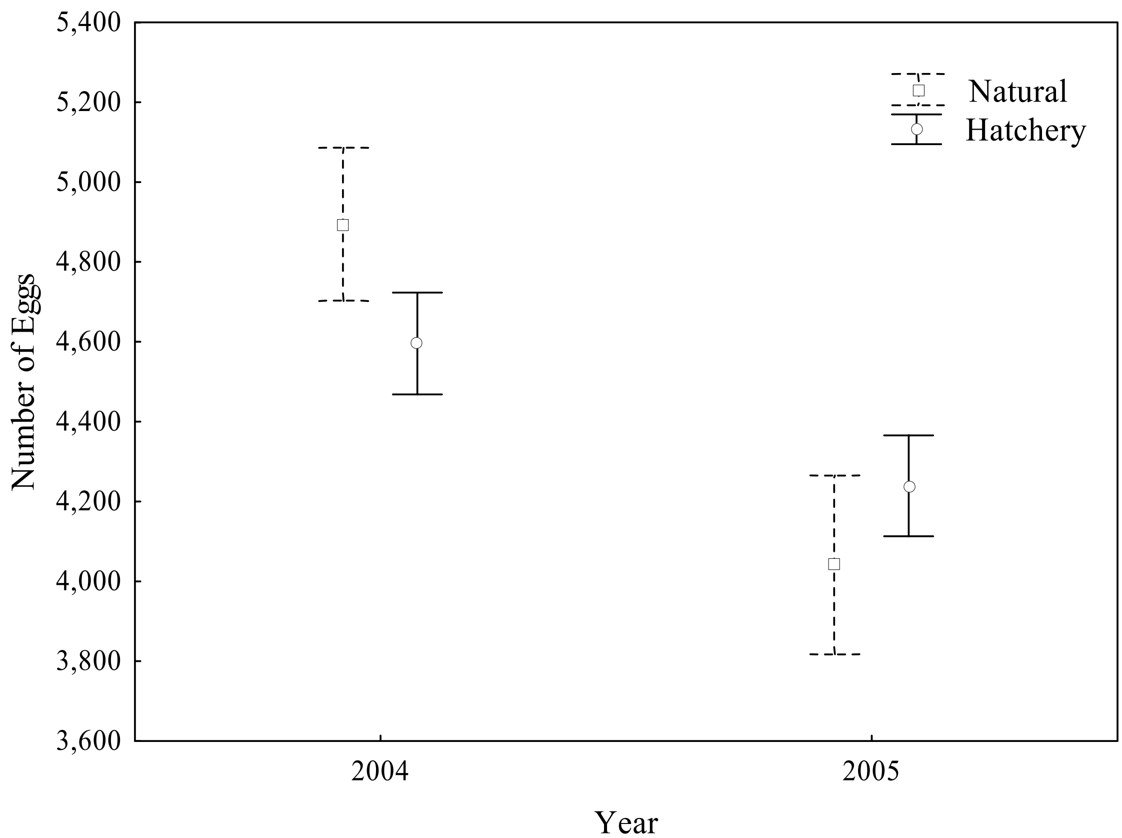

Figure 4. Mean fecundity age-4 hatchery and natural origin Chiwawa spring Chinook. Vertical bars denote 95% confidence intervals.

Egg Retention

A total of 378 hatchery and 79 naturally produced fish were examined to determine the number of eggs retained in the body cavity after spawning (Table 10). The proportion of eggs retained was estimated using fecundity linear regression models for hatchery and natural origin fish derived from hatchery broodstock (Table 11). The estimated mean (SD) percentage of eggs retained for hatchery and naturally produced fish was 0.48 (1.9) and 0.34 (1.2), respectively. A Kruskal-Wallis ANOVA was used to test for differences between origin and spawning location because assumptions of normality and equal variances could not be met. No difference was detected in the proportion of eggs retained between hatchery and naturally produced fish ($P = 0.22$). Significant differences were detected between the Chiwawa River and both the Wenatchee River and Nason Creek. The Wenatchee River was also significantly different from the White River ($P < 0.001$). Further analysis by location and origin found that only the hatchery fish in the Wenatchee River had a significantly higher egg retention rate than both hatchery and wild fish in the Chiwawa River ($P < 0.001$). Overall egg retention rates did not differ between 2004 and 2005 ($P = 0.16$). When between year comparisons were conducted by group (i.e., year, stream, and origin), no significant differences were detected other than those differences found in 2005.

Table 10. Number of female spring Chinook examined and the mean number of eggs retained in the body cavity after spawning in 2004 and 2005.

Stream	Hatchery			Natural		
	N	Mean	SD	*N*	Mean	SD
			2004			
Chiwawa	22	63	255	32	13	53
Nason	14	37	75	56	12	42
Wenatchee	6	10	6	3	2	4
White	2	10	13	5	5	11
Little Wenatchee	0	--	--	1	8	--
			2005			
Chiwawa	179	11	47	35	10	51
Nason	98	31	106	25	21	52
Wenatchee	46	46	107	1	0	
White	32	3	6	7	1	2
Little Wenatchee	23	5	8	11	21	59

Table 11. Estimated mean percentage of eggs retained in the body cavity of female spring Chinook examined on the spawning grounds in 2004 and 2005.

Stream	Hatchery	Natural

	N	Mean	SD	*N*	Mean	SD
			2004			
Chiwawa	22	1.35	5.40	35	0.27	1.13
Nason	14	0.86	1.79	55	0.26	0.93
Wenatchee	7	0.19	0.17	3	0.04	0.07
White	2	0.28	0.40	5	0.13	0.22
Little Wenatchee	0	-	-	1	0.20	-
			2005			
Chiwawa	179	0.26	1.06	35	0.26	1.35
Nason	98	0.81	2.92	25	0.50	1.30
Wenatchee	46	1.12	2.51	1	0.00	-
White	32	0.07	0.15	7	0.01	0.04
Little Wenatchee	23	0.13	0.22	11	0.46	1.24

Spring Chinook Potential Spawning Population

Based on PIT detections and information collected at Tumwater Dam, Eastbank FH, Chiwawa weir, and other Columbia River dams, the number of spring Chinook remaining upstream of Tumwater Dam that could spawn was 3,475 adults and jacks and 297 hatchery precocious males (Table 12).

Table 12. Distribution of spring Chinook detected at Tumwater Dam in 2004 and 2005. Data includes eight natural and one hatchery origin spring Chinook detected from video counts in 2004 and three natural origin spring Chinook detected from video counts in 2005 (HPM = hatchery precocious males).

Origin	Below Tumwater Dam		Above Tumwater Dam			
	Fallback	Eastbank Hatchery	Prespawn Mortality	Chiwawa Weir	Spawning Grounds	Total
2004						
Hatchery	11	148	2	48	1,124	1,333
HPM	0	0	0	0	635	635
Natural	0	4	7	93	792	896
Unknown	0	0	0	0	32	32
Total	11	152	9	141	2,583	2,896
2005						
Hatchery	0	40	54	143	2,983	3,220
HPM	0	0	0	0	297	297
Natural	0	0	10	99	464	573
Unknown	0	0	5	1	28	34
Total	0	40	69	243	3,772	4,124

Summary

In 2005, the natural escapement and hatchery production levels affected the differences in sex ratios and age distribution of hatchery and natural origin fish. Differences in size at return examined over time could prove useful in detecting affects of hatchery fish on size at return of natural origin fish. This was the first year in which within year differences between hatchery and wild age-4 spring Chinook have been detected. Chiwawa adult hatchery spring Chinook have been typically larger than their wild cohorts, but differences were not statistically significant. Size of hatchery origin spring Chinook salmon adults in the Tucannon River were smaller than natural origin spring Chinook salmon during the initial years of hatchery operation but later the differences could not be detected (Gallinat 2004). Similarly, first generation hatchery origin spring Chinook salmon in the upper Yakima River were smaller than natural origin fish (Knudsen et al. in press). Differences observed in the Wenatchee Basin may be because of the larger size disparity of hatchery and natural origin smolts. In addition, the record high spring Chinook escapement in 2001 may have also affected the size of returning adults. For example, density dependent growth may have caused the small size of smolts that emigrated in 2003. The mean fork length of the 2001 brood Chiwawa spring Chinook smolts in 2003 was 86 mm, the smallest size at emigration detected since monitoring began in 1993 (average between 1993 and 2002 = 96 mm; WDFW unpublished data).

Female hatchery and natural origin spring Chinook have similar length-fecundity relationships. Mean fecundities of both hatchery and natural are also similar within years, but may be different between years. These results suggest that fecundity of both hatchery and natural spring Chinook respond similarly to changes in environmental conditions.

Acknowledgements

The Bonneville Power Administration provided funding for this project. We thank Jonathan McCloud, the administrator for this project, for supporting our unique contracting requirements. We would like to thank Chelan County Public Utility District and the Yakama Nation for providing the expertise and funding for the design and construction of the Tumwater Dam fish trapping facilities. We would also like to thank Clint Deason, Kelly Behne, Brain Johanson, Nathan Dietrich, and Zeke Simmons for their assistance in operation of Tumwater Dam fish trap and collecting data from all fish trapped. Mike Tonseth and the hatchery personnel at Eastbank Complex provided the data on the hatchery broodstock. John Sneva of the WDFW Scale Lab read all the scale samples.

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Chapter 2

Population genetic analyses, pedigree reconstruction and fitness estimation

Abstract

Hatcheries have been increasingly asked to contribute to conserving natural salmon populations, as well as to continue to produce fish to mitigate for lost harvest opportunities. A key biological uncertainty about the effects of hatchery production on natural populations is the degree to which hatchery produced fish can reproduce in the

natural environment. In order to assess the impact (positive or negative) of supplementation of spring Chinook salmon in the Wenatchee River we are using a DNA-based pedigree analysis to (1) directly measure the relative reproductive success of hatchery and natural-origin spring Chinook salmon in the natural environment, (2) determine the degree to which any differences in reproductive success between hatchery and natural Chinook salmon can be explained by measurable biological characteristics such as run timing, morphology, and reproductive behavior, and (3) estimate the relative fitness of fish produced by hatchery-origin adults breeding in the natural environment and that have themselves returned to spawn.

Population genetic and preliminary parentage analyses have been carried out during the second year of monitoring reproductive success of naturally spawning hatchery and natural Spring Chinook salmon in the Wenatchee River. Eleven microsatellites were used to analyze population genetic structure for 2,969 adult Spring Chinook entering the Wenatchee R. drainage system during 2004. Significant genetic differentiation exists between adult hatchery and wild fish, and between wild adults returning to spawn in the Chiwawa River, Nason Creek, and the White River. Wild and hatchery samples have similar overall levels of genetic diversity, but patterns of diversity within each group differ. The wild samples are characterized by a slight heterozygote deficit (compared to random mating expectations), and generally have low levels of statistical associations among loci. In contrast, the hatchery samples are characterized by a slight heterozygote excess compared to random mating expectations, and have high levels of statistical associations among loci. These patterns probably reflect differences in effective population size or family structure between the two groups.

Preliminary testing of parentage assignment rates of 2004 Wenatchee R. Spring Chinook, performed separately for wild and hatchery fish, indicated assignment success rates (proportion of simulations in which the most likely parent pair was the correct parent pair) were 97.8% and 82.7% for wild and hatchery fish, respectively. When a statistical criterion was used to limit incorrect assignments to no more than 5%, the total assignment rate dropped to 66.1% for the hatchery fish. These results reflect the higher degree of non-independence among loci observed for hatchery compared to wild fish and appear to be a consequence of the low numbers of spawners that produced the 2004 hatchery return. In order to predict the effects of adding additional loci to the analysis, a subset of several hundred of the 2004 adults were genotyped at an additional four loci (for a total of 15 loci). For the 2004 returns (~1800 hatchery origin fish), we predict ~90% of the time the parent pair with the highest likelihood would be the true parents using the 15 locus dataset, compared to 82.7% for the 11 locus set. Increasing the number of microsatellite loci genotyped will therefore be necessary to boost the power of parentage assignment in order to limit incorrect assignments to < 5% for hatchery fish. Even with the 11 locus dataset, we were able to make some inferences about fitness differences between hatchery and wild fish, however. For example, 2 and 3 year old hatchery males made up a large fraction of the male fish sampled at Tumwater Dam, but even after accounting for differences in assignment success, appeared to be very unsuccessful at producing progeny.

Introduction

Hatcheries have been increasingly asked to contribute to conserving natural salmon populations, as well as to continue to produce fish to mitigate for lost commercial, recreational, and tribal harvest opportunities. For example, supplementation projects, in which adult hatchery fish are deliberately encouraged to spawn naturally to augment a population's abundance, have become common throughout the Columbia River Basin. However, little direct data are available regarding the beneficial or harmful influence hatchery production has on the natural production of Chinook salmon.

A key biological uncertainty about the effects of hatchery production on natural populations is the degree to which hatchery produced fish can reproduce in the natural environment. Accurately measuring the biological causes of variance in reproductive competence is important not only for determining the benefits of conservation hatcheries, but also for risk assessment of fish that stray from 'production' type hatcheries. For instance, if the relative reproductive success of hatchery fish is low, a supplementation program is unlikely to be successful at increasing natural production. Evaluating relative reproductive success is therefore critical for determining if the considerable investment the region has made in hatchery supplementation programs is actually contributing to (or even impeding) the recovery of salmon populations. Determining the relative reproductive success of hatchery fish that stray from traditional hatchery programs is also important. Stray hatchery fish can often mask the status of natural populations because their reproductive success is unknown, and may lead to reduced short and long-term natural productivity due to genetic deterioration of the natural population as a result of interbreeding between naturally produced fish and some hatchery strays. By directly quantifying the reproductive success of stray hatchery fish in the natural environment relative to that of fish from the natural population, the viability of natural populations receiving substantial stray hatchery fish can be much more accurately evaluated.

This goal of this project is to quantitatively assess the relative reproductive success of naturally spawning hatchery and natural origin spring-run Chinook salmon in the Wenatchee River by employing a molecular genetic pedigree analysis. Specifically, we will (1) directly measure the relative reproductive success of hatchery and natural-origin spring Chinook in the natural environment, (2) determine the degree to which any differences in reproductive success between hatchery and natural Chinook salmon can be explained by measurable biological characteristics such as run timing, morphology, and reproductive behavior, and (3) estimate the relative fitness of fish produced by hatchery-origin adults breeding in the natural environment and that have themselves returned to spawn.

A baseline genetic data set for Wenatchee R. Spring Chinook has been developed using data on adult fish collected during 2004. Data for the 2005 adults and juveniles are still being collected. In addition, a preliminary evaluation of parentage assignment has been made using data from subsets of the 2004 adults and 2005 juveniles. In this report, we describe patterns of genetic variation within and among spawning populations of spring Chinook salmon in the Wenatchee River and within and between hatchery and natural origin fish. We also describe the results from our preliminary parentage analyses, using both simulated and real progeny from the 2004 parents sampled at Tumwater Dam.

Methods

Sampling - Washington Department of Fish and Wildlife (WDFW) personnel obtained fin and scale samples from 2969 and 4098 adult spring-run Chinook as they were being passed over the Tumwater Dam fish weir from May to August 2004 and 2005, respectively. A higher number of 2004 spring Chinook adults are reported on here (compared to 2896 fish reported on in the first annual report) due to subsequent reanalysis of individuals that did not initially produce data. These samples represent adult spring-run fish returning to spawn in the major tributaries (primarily the Chiwawa River, Nason Creek, and the White River) of the Wenatchee River. Other data collected during sampling included fork length, weight, secondary sexual characteristics, and presence of adipose fin. The age as well as hatchery origin of fish was evaluated by scale growth pattern analysis (John Sneva, WDFW, personal communication). All sampled spring-run Chinook salmon were also PIT tagged at Tumwater Dam. Individuals re-sampled on the spawning grounds as carcasses were evaluated for the presence of a coded wire tag (CWT) or PIT tag. WDFW also provided dried fin-clip samples from 350 Leavenworth National Fish Hatchery (Carson stock) Spring-run Chinook adults that had been out-planted from Peshastin Creek in 2004,192 Wenatchee R. Summer-run Chinook adults collected during 2004, and 48 Chiwawa R. Hatchery Spring Chinook collected in 1994.

We also took advantage of another study in which juvenile Spring Chinook salmon were temporally detained in rotary screw traps as they migrated down stream in the Chiwawa R., Nason Crk., and White R. Fin-clips were sampled from 1,210 juveniles during 2005, but only ~196 of these have been genotyped to date.

Microsatellite genotyping - Genomic DNA was extracted from fin clips using a QIAgen DNA tissue extraction kit, eluted into a 96-well sample plate, and quantified using a FLX 800 Microplate Fluorescence reader (Bio-Tek Instruments, Winooski, Vermont). All original DNA extractions as well as the working stocks of DNA were stored at -20^{o}C until needed. Unused portions of fin-clips have been appropriately cataloged and stored. Individuals were genotyped at 11 previously developed di- and tetranucleotide repeat microsatellite loci: Ots3, Ots104, Ots201b, Ots211, Ots213, Ots2M, Ots10M, OtsD9, Oke4, Ogo4, and Ssa408 (references provided in Table 1). A subset of 384 adults and 192 juveniles collected during 2004 and 2005, respectively, were genotyped at four additional tetranucleotide repeat microsatellite loci: Ogo2, Oki23MMBL, Omy1011, and Ots208b (references provided in Table 1). The growth hormone pseudogene locus (GH-Ψ) (Du et al. 1993) was used to estimate the sex of each individual. Microsatellite alleles were amplified by Polymerase Chain Reaction (PCR) assays using 15 ng of genomic DNA, 1.75 or 2.0 mM $MgCl_2$, 0.2 mM each dNTP, 0.2 μM of each PCR primer, 0.25 Units of T_{aq} DNA polymerase (Promega Biosciences, San Luis Obispo, California), 20 mM Tris (pH 8.5) and 50 mM KCl in 10 μl volumes. The forward primer of each PCR primer pair was labeled with a fluorescent phosphoamidite (FAM, NED, PET, or VIC). Tetrad thermal cyclers (MJ Research, San Francisco, CA) were programmed with the conditions, shown in Table 1, which permitted pairs of loci to be co-amplified (duplexed) into single PCR reactions. Each set of PCR conditions (Table 1) included a lengthy final extension cycle used to “fill-in” the +A nucleotide additions Taq DNA polymerase creates at the 3’-end of each synthesized DNA strand thereby permitting more consistent and accurate scoring of PCR products. PCR products and in-lane size standards (GeneScan 500) were resolved using an ABI3100 capillary electrophoresis system (Applied Biosystems, Inc., Foster City, California). Individual genotypes were scored using Genotyper software (Applied Biosystems, Inc., Foster City, CA). Prior to assigning genotypes to individual samples, the raw, un-binned data for every allele detected was plotted on a locus by locus basis. This pre-screen of the data set was performed in order to ascertain whether or not shifts in allele mobility occurred during the period of data collection. Genotyping error rate per locus (Table 1) was determined by re-amplifying and re-scoring microsatellite loci for a subset of individuals, and calculating the number of alleles mis-scored over the total number of alleles observed at each locus. Genotypic sex, according to GH-Ψ (Du et al. 1993), and phenotypic sex were compared for 240 Spring-Run Chinook adults collected as brood stock during the 2004 sampling period.

Table 1 -- Thermocycler conditions, genotyping error rate, and references for 15 microsatellite loci and one sex-specific locus (GH-Ψ) used to evaluate the 2004 Wenatchee River Spring-Run Chinook adults. Thermocycler conditions for each pair of loci simultaneously amplified (duplexed) in a single PCR reaction include: one denaturation cycle at 95 ^{o}C for 150 seconds, amplification cycles of 95 ^{o}C for 40s, X ^{o}C annealling temperature (T_m ^{o}C) for 40s, 72 ^{o}C for 40s, and a final extension cycle of 60 ^{o}C for 45 min.

Locus Name	$MgCl_2$ (mM)	T_m (^{o}C)	Genotyping % Error Rate	References
Oke4	1.75	54	1.43	Buchholz et al. 1999
Oki23MMBL	1.75	54	NDa	Spidel et al., unpublished
Ogo2	1.75	60	NDa	Olsen, Bentzen, and Seeb 1998
Ogo4	1.75	60	1.53	Olsen, Bentzen, and Seeb 1998
Omy1011	1.75	54	NDa	Bentzen et al. 2001
Ots2M	2.00	60	1.39	Greig and Banks 1999
Ots3	1.75	48	0.60	Banks et al. 1999
Ots10M	1.75	54	0.95	Greig and Banks 1999
OtsD9 (Ots519NWFSC)	1.75	54	1.43	Naish and Park, 2002
Ots104	1.75	48	1.46	Nelson and Beacham 1999
Ots201b	2.00	60	1.55	none
Ots208b	1.75	60	NDa	Grieg, Jacobson, and Banks 2003
Ots211	1.75	60	0.68	Grieg, Jacobson, and Banks 2003
Ots213	1.75	54	1.30	Grieg, Jacobson, and Banks 2003
Ssa408	2.00	60	1.22	Cairney, Taggert, and Hoyheim 2000
Growth Hormone psuedogene	2.00	60	2.50	Du et al. 1993

[a] Genotyping error rate not determined for locus.

Identifying Summer-Run and stray Spring-Run hatchery fish- The putative Wenatchee R. Spring Chinook data set was evaluated for admixture with Summer-Run fish. Putative Spring Chinook were assigned to either a Spring- or Summer–Run baseline population using the software program Genetic Mixture Analysis (GMA) (Kalinowski 2003). The first 574 (out of 2969) Spring-Run Chinook adults collected at the Tumwater Dam weir and 192 Summer-Run Chinook adults collected from the Wenatchee River in 2004 were used as Spring- and Summer-Run Chinook baseline population data, respectively. The sample data set of putative Spring Chinook adults contained the remaining 2395 individuals. Jack-Knife analyses of baseline populations were performed with WHICHRUN V.4.1 (Banks and Eichert 2000) to characterize the robustness of assignments to the Spring- and Summer-Run populations. Log of odds (LOD) scores, the log of the ratio of the probability that an individual's genotype occurs in one population compared to another population, were calculated for each individual. Individuals with LOD scores >2 (100X more likely to be assigned to one population than another population) assigned to specific populations; individuals with LOD <2 were considered ambiguous. Putative "spring" Chinook with genotypes that assigned to the Summer-Run baseline, had an ambiguous assignment, had an origin that could not be ascertained, or that carried a LNFH CWT were not used for population genetic analyses. All fish that were not positively identified as summer Chinook were used in the parentage assignment analyses.

For population structure analyses, the positively identified Wenatchee R. Spring Chinook (N=2823) were grouped according to hatchery (N=1947) or wild (N=876) origin. Hatchery fish were initially identified as having an adipose fin-clip and/or CWT. Wild fish were initially identified by the presence of an adipose fin. To confirm these assignments, scale growth pattern analysis (John Sneva, WDFW, personal communication) was used to positively discriminate hatchery vs. wild origin. When sample sizes were sufficiently large to provide meaningful comparisons (n>~50), hatchery and wild fish were analyzed separately by carcass recovery location (Chiwawa River, Nason Creek, or White River) and age.

The numbers of Spring Chinook adult carcasses collected on the White R. in 2004 and 2005 (N= 11 and 29, respectively) were too low to provide an adequate representative sample of the White R. population in each year alone. However, combining the adult carcass recovery samples from both years with a subset of juvenile fish sampled in the White R. during 2005 provided a reasonable sample size. To avoid over representation of only a few families in the available 2005 White R. juvenile sample (N=70), pair-wise relatedness values for all possible combinations of juveniles were calculated using the software program Pedigree v.2.0 (provided by Christophe Herbinger, Dalhousie University). Pedigree v.2.0 uses the pair-wise relatedness score approach described in Smith et al. (2001) to partition individuals into full sib families without parental information. The size and membership of full-sib groups were stable over a wide variety of Monte Carlo Markov-Chain simulation parameters. By selecting only one individual from each full sib group or doublet and all other juveniles not partitioned to a group, nonrelated juveniles (N=27) collected during 2005 were added to the sample of 2004 and 2005 adults to achieve an overall larger sample size (N=67) for the White R. population.

The presence of stray Leavenworth National Fish Hatchery (LNFH) Spring-Run fish within the 2004 Wenatchee R. hatchery and wild Spring Chinook datasets was investigated prior to quantifying population genetic statistics and performing cluster analyses. One of the adipose fin clipped adult Spring Chinook sampled at the Tumwater Dam weir carried a Leavenworth CWT. This fish was used as a reference to help determine which fish, if any, in the 2004 Wenatchee R. Spring Chinook samples might originate from the LNFH. Putative assignment of Wenatchee R. Spring Chinook to either the LNFH or Wenatchee R. Spring-Run baseline population was carried out using WHICHRUN V.4.1 (Banks and Eichert 2000). Baseline datasets included the 2004 Peshastin Creek Hatchery Spring adult out-plants (N=350) used as a proxy for LNFH Spring-Run, 2004 Wenatchee R. Summer-Run adults (N=192), and the 2004 Wenatchee R. Spring-Run wild adults (N=876). Individual assignment of Wenatchee river Spring-run Chinook hatchery fish to the LNFH baseline population was carried out using a LOD score criterion of 2. The hatchery fish sample set included 1948 fish, including the single LNFH CWT recovery. Because of the relatively large genetic differences between Spring- and Summer –run fish, the robustness of assignment of Wenatchee R. hatchery Spring Chinook to the LNFH baseline population was tested by re-performing assignment testing after removal of the Summer Chinook sample from the of baseline dataset.

Characterization of microsatellite loci – Microsatellite loci were characterized separately in hatchery and wild Chinook populations, as well as in hatchery fish grouped by age, and wild fish grouped by carcass recovery location. Allele frequencies, the total number of observed alleles, expected heterozygosity (H_e) under Hardy-Weinberg equilibrium (HWE), observed heterozygosity (H_o), and F_{IS} values (and their 95% confidence intervals) for the first 11 microsatellite loci were calculated using the program GENETIX version 4.05 (Belkhir et al. 2000, available at http://www.University-montp2.fr/~genetix/genetix.htm). Pair-wise comparisons of loci for linkage disequilibrium were made by estimation of exact P-values by the Markov chain method (Guo and Thompson 1992) as implemented in GENEPOP (dememorization steps 1000; 50 batches; 1000 iterations per batch). Sequential Bonferroni adjustments to α were applied, where appropriate, for simultaneous tests to decrease the chance of erroneously rejecting null hypotheses (Rice 1989).

Characterization of Spring Chinook population structure – Pair-wise F_{ST} matrices were calculated using GENETIX V4.05 (Belkir et al. 2003). The Peshastin Creek Hatchery Spring-Run outplant and Wenatchee R. Summer-Run samples were included in the analysis of Wenatchee R. Spring Chinook. Significance ($\alpha < 0.05$) of pair-wise F_{ST} values was assessed using 1000 bootstrap replicates of the entire data set. Unrooted Neighbor-Joining phenograms, based on Cavalli-Sforza (1967) cord distance units, were created with PHYLIP (Felsenstein 1989). The phenograms were constructed using data from the first 11 microsatellites, 1000 boot-strap replicates of the data set, and were 're-rooted' through the 2004 Wenatchee R. Summer-Run Chinook out group.

Parentage assignment – Our first planned sampling of progeny for this project will occur in spring of 2006, when smolts produced from the 2004 spawning year will be captured in the lower Wenatchee River near Monitor. However, we took advantage of another ongoing sampling program in the Wenatchee River tributaries to obtain samples from 2004 broodyear parr collected from the Chiwawa River, Nason Creek, and White River in fall/winter of 2005. We conducted a preliminary parentage analyses of 196 of these parr, all collected from the Chiwawa River.

Parentage assignments were made using the likelihood methods of Meagher and Thompson (1986) and Gerber et al. (2000) as implemented in the program FAMOZ (Gerber et al. 2003). Each individual in a sample of progeny was tested against all potential pairs of parents (discarding information on parent sex) and a log of odds (LOD) score was calculated for each potential parent pair/offspring triplet as the log of the ratio of the probability of a parent pair/offspring relationship compared to the probability they were drawn randomly from the population. The most likely pair of parents was compared to the second most likely and the difference in LOD scores (Δ LOD) was calculated. The simulation function of the FAMOZ program was used to generate expected distributions of Δ LOD scores for correct and incorrect assignments.

Simulations and actual parental assignments were conducted assuming a genotyping error rate of 1.5% per locus, and an analysis error rate of 0.01% per locus (i.e., the rate at which errors were produced in the simulations was 1.5% per locus, but the error rate assumed in the analysis of the simulated and real data was 0.01% per locus). The 1.5% error rate is approximately equal to what we have observed in our laboratory, and the 0.01% analysis error rate was used because it produced a higher fraction of correct assignments in the simulations than did an error rate of either 1.5% or 0. In general, the highest fraction of correct assignments were obtained with a non-zero but small error rate, similar to what has been reported previously (Gerber et al. 2000; Sancristobal and Chevalet 1997).

Results

Genotyping error rates – The overall genotyping error rate for the microsatellite loci was 1.23% and ranged from 0.60% (Ots3) to 1.55% (Ots201b). Out of the 240 Spring-Run brood stock examined six (2.5%) had a GH-Ψ genotype that was incongruent with its gonad phenotype. Inconsistencies included phenotypic male fish lacking the male-specific PCR fragment (~274 bp), and phenotypic females that were positive for the male-specific PCR fragment. The percentage of mismatches between genotypic and phenotypic sex on the Wenatchee R appears to be similar to that observed in other Columbia River Basin Spring Chinook populations (Devlin et al. 2005) and smaller than that observed in some Fall Chinook populations (Chowden and Nagler 2005).

Differentiation between spring and summer run Chinook -- Assignment testing of 2395 Wenatchee R. putative Spring-Run fish to either the Spring- or Summer–Run baseline data revealed 97 Summer-Run and three ambiguously assigned individuals. All 100 of these fish, another 41 individuals whose origin could not be determined and five individuals carrying LNFH CWTs were removed from the Spring Chinook dataset prior to further population genetic analyses. Jack-Knife analyses of assignment to the Spring- and Summer–Run baseline populations indicated a very high percentage of correct assignments (99.5% and 100%, respectively). The remaining 2823 (2249 assigned to Wenatchee Spring-Run plus the first 574 fish collected at Tumwater Dam used as a 'pure' Spring baseline population) individuals in the Wenatchee R. Spring Chinook dataset were grouped into 1947 hatchery and 876 wild origin fish. These 1947 hatchery Spring Chinook include putative LNFH strays.

A total of 57 hatchery and zero wild Spring Chinook were identified as potential LNFH strays based on their genotypes (data not shown). The known Leavenworth CWT individual was assigned to the Peshastin Creek Hatchery baseline population with a LOD score of 2.44. An additional four LNFH CWT fish were recovered as carcasses on Nason Creek (Travis Maitland, WDFW, personal communication). Only one out of these four LNFH CWT bearing fish was assigned (LOD>3) to the LNFH proxy baseline. The poor ability to discriminate LNFH CWT bearing fish within the 2004 Wenatchee R. Spring Chinook sample suggests that some un-tagged LNFH origin fish are present in the sample of Wenatchee R. Spring Chinook (Table 2). Because we did not feel confident in our ability to assign individual Spring-run Chinook salmon to the LNFH or Wenatchee River populations, only the five LNFH CWT fish were removed from the dataset prior to conducting population genetic analyses. All Spring-run Chinook salmon, including the five with LNFH tags, were used in the parentage analyses, however.

Table 2 -- Jack-Knife analyses of reassignment of individuals back to their original baseline (critical) population using WHICHRUN V.4.1 (Banks and Eichert 2000) and a LOD threshold of 2.0. The number of individuals per critical population (N) and the number of individuals correctly reassigned back to their own baseline population are shown. Numbers of incorrectly assigned individuals and the baseline population to which they were mis-assigned are presented in the last three columns.

Critical Population	N	# Correctly Reassigned to Crit. Pop.	# Incorrectly Assigned: Peshastin Outplants	Spring Hatchery	Spring Wild
2004 Summer-Run adults	192	188	0	0	0
Peshastin Crk. Spring-Run outplants	350	85	--	1	4
2004 Spring Hatchery adults	1947	162	0	--	
2004 Spring Wild adults	876	28	0	2	--

Summary of variation -- Basic population genetic statistics were calculated for 1947 hatchery and 876 wild Wenatchee R. Spring Chinook (Table 3A and 3B, respectively). For the combined 2004 hatchery Spring Chinook (Table 3A) the number of observed microsatellite alleles ranged from 6 (Ots10M) to 46 (Ots104). A small excess of heterozygous genotypes was indicated by negative F_{IS} values for five out of nine loci significantly (α=0.0045) different from HW expectations (Table 3A). Out of 55 pair-wise comparisons of loci, 48 (87%) had nonrandom (significant α=0.0045) allelic associations (Linkage Disequilibrium, LD). Too few hatchery Spring-Run fish could be grouped based on carcass recovery location to perform statistically relevant analyses. Hatchery Spring Chinook were grouped according to age and the analyses repeated. Similar results (not shown) were obtained as for the combined hatchery fish data. In contrast, the sample of 1994 Chiwawa R. Hatchery Spring Chinook showed no significant (α=0.0045) deviations from HW equilibrium at the eight microsatellite loci examined and no LD (Table3C). Since the sample size (N=48) of the 1994 hatchery fish is much lower than that examined in 2004 (N=1947), the observed number of alleles/locus in the 1994 sample is lower as well.

Table 3 -- Population genetic statistics of 11 microsatellite loci for the 2004 Wenatchee River combined hatchery (A) and wild (B) Spring-Run Chinook, and 8 microsatellite loci for the 1994 Chiwawa R. Hatchery sample (C). Observed number of alleles (n), expected and observed heterozygosities (H_e and H_o, respectively), and Hardy-Weinberg equilibrium (F_{IS}, Weir & Cockerham 1984) are shown. The 95% confidence intervals for F_{IS} values were calculated by bootstrapping 500 times using the software package GENETIX4.05 (Belkhir et al. 2000). The p-values for were calculated using the software package GenePop3.4 (Raymond and Rousset 1995). * F_{IS} values statistically significant at α = 0.0045.

A – 2004 Hatchery fish

Msat Locus	Obs. # Alleles	H_e	H_o	F_{IS} value	95% CI	p-value
Ogo4	13	0.81	0.81	-0.007*	(-0.031 - 0.014)	<0.001
Ots10M	6	0.53	0.51	0.046	(0.001 - 0.090)	0.029
Ots211	27	0.94	0.93	0.005*	(-0.006 - 0.016)	<0.001
Ots213	32	0.91	0.93	-0.022*	(-0.035 - -0.010)	<0.001
Ots2M	14	0.54	0.56	-0.042	(-0.081 - 0.005)	0.018
Oke4	7	0.62	0.61	0.014*	(-0.015 - 0.045)	<0.001
Ots104	57	0.95	0.96	-0.012*	(-0.021 - -0.003)	<0.001
Ots201b	31	0.93	0.95	-0.022*	(-0.033 - -0.011)	<0.001
Ots3	13	0.64	0.66	-0.038*	(-0.067 - -0.009)	<0.001
OtsD9	9	0.70	0.66	0.059*	(0.029 - 0.090)	<0.001
Ssa408	29	0.89	0.86	0.031*	(0.015 - 0.048)	<0.001
All loci		0.77	0.77	<0.001*	(-0.006 - 0.006)	<0.001

total # individs used = 1947

B – 2004 Wild fish

Msat Locus	Obs. # Alleles	H_e	H_o	F_{IS} value	95% CI	p-value
Ogo4	13	0.81	0.79	0.024	(-0.004 - 0.060)	0.278
Ots10M	5	0.54	0.52	0.038	(-0.019 - 0.093)	0.614
Ots211	28	0.93	0.94	-0.011*	(-0.027 - 0.005)	<0.001
Ots213	33	0.91	0.90	0.010	(-0.009 - 0.031)	0.005
Ots2M	14	0.56	0.53	0.054	(-0.002 - 0.108)	0.448
Oke4	7	0.60	0.55	0.094	(0.048 - 0.142)	0.010
Ots104	49	0.95	0.92	0.027*	(0.012 - 0.043)	<0.001
Ots201b	34	0.93	0.92	0.012*	(-0.005 - 0.030)	<0.001
Ots3	8	0.55	0.53	0.032*	(-0.017 - 0.076)	0.001
OtsD9	5	0.70	0.72	-0.034*	(-0.080 - 0.009)	<0.001
Ssa408	24	0.90	0.86	0.043	(0.017 - 0.069)	0.076
All loci		0.76	0.76	0.023*	(0.012 - 0.034)	<0.001

total # individs used = 876

C. – 1994 Chiwawa River Hatchery fish

Msat Locus	Obs. # Alleles	H_e	H_o	F_{IS} value	95% CI	p-value
Ogo4	9	0.78	0.80	-0.017	(-0.156 - 0.111)	0.770
Ots10M	4	0.54	0.43	0.220	(-0.015 - 0.486)	0.261
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Ots2M	4	0.55	0.39	0.304	(0.029 - 0.541)	0.027
Oke4	5	0.55	0.57	-0.011	(-0.272 - 0.268)	0.183
Ots104	28	0.94	0.96	-0.006	(-0.066 - 0.056)	0.732
--	--	--	--	--	--	--
Ots3	6	0.63	0.67	-0.042	(-0.217 - 0.096)	0.083
OtsD9	4	0.65	0.59	0.108	(-0.081 - 0.336)	0.373
Ssa408	15	0.87	0.85	0.035	(-0.087 - 0.135)	0.936
All Loci		0.69	0.66	0.061	(-0.008 - 0.097)	0.160

total # individs used = 48

For the combined 2004 wild Spring Chinook population (Table 3B) the number of observed microsatellite alleles ranged from 5 (Ots10M and OtsD9) to 49 (Ots104). Three loci (Ots104, Ots201b, and Ots3) had slightly fewer heterozygous genotypes (indicated by significantly (α=0.0045) positive F_{IS} values) than expected under HW equilibrium (Table 3B). Over all 11 loci combined, the wild population had about 2.3% fewer heterozygotes than expected under random mating assumptions (F_{IS} = 0.023, p<0.001). Analysis of Linkage Disequilibrium indicated 14 of 55 (25%) pair-wise comparisons of loci had significant (α=0.0045) allelic associations.

Population genetic statistics were also calculated for subsets of wild fish recovered as carcasses on the Chiwawa R. (N=106), Nason Crk. (N=85), and the White R. (N=67; Table 4A, B, and C, respectively). The multilocus F_{IS} values for the Chiwawa R. (F_{IS} = 0.022, p=0.002) and Nason Crk. (F_{IS} = 0.012, p=0.002) wild Spring Chinook were significantly different from HW equilibrium. The White R. Spring Chinook population, which included adults collected during 2004, as well as adults and juveniles collected during 2005, did not deviate significantly from HW equilibrium after correction for multiple tests, but the estimate of F_{IS} was numerically similar to the other populations (F_{IS} = 0.020, p=0.036). Sub-grouping wild fish based on carcass recovery location resulted in fewer individual loci within the Chiwawa R., Nason Crk., and White R. wild Spring-Run populations (0, 2, and 0, respectively) deviating from HW equilibrium, and the percentage (4%, 2%, and 2%, respectively) of pair-wise comparisons of loci in LD decreased. Most (96%) of the 876 wild Spring Chinook sampled were 4 year old fish. Accordingly, statistically relevant analyses based on the age of wild fish could not be performed.

Table 4 -- Population genetic statistics of 11 microsatellite loci for the 2004 wild Chiwawa R. (A), Nason Creek (B), and White R. (C) Spring-Run Chinook. The White R. sample includes adults collected during 2004-5 and juveniles collected during 2005. Observed number of alleles (n), expected and observed heterozygosities (H_e and H_o, respectively), and Hardy-Weinberg equilibrium (F_{IS}, Weir & Cockerham 1984) are shown. The 95% confidence intervals for F_{IS} values were calculated by bootstrapping 500 times using the software package GENETIX4.05 (Belkhir et al. 2000). The p-values for were calculated using the software package GenePop3.4 (Raymond and Rousset 1995). * F_{IS} values statistically significant at $\alpha = 0.0045$.

A. – Chiwawa River wild

Msat Locus	**Obs. # Alleles**	**H_e**	**H_o**	**F_{IS} value**	**95% CI**	**p-value**
Ogo4	10	0.81	0.69	0.151	(0.058 - 0.260)	0.008
Ots10M	4	0.55	0.57	-0.030	(-0.209 - 0.109)	0.054
Ots211	19	0.92	0.94	-0.020	(-0.068 - 0.029)	0.516
Ots213	24	0.89	0.88	0.014	(-0.050 - 0.079)	0.179
Ots2M	6	0.55	0.60	-0.093	(-0.039 - 0.104)	0.752
Oke4	6	0.60	0.48	0.192	(0.057 - 0.316)	0.009
Ots104	31	0.93	0.87	0.068	(0.009 - 0.126)	0.131
Ots201b	22	0.92	0.94	-0.022	(-0.070 - 0.026)	0.034
Ots3	7	0.59	0.60	-0.018	(-0.157 - 0.112)	0.598
OtsD9	4	0.69	0.73	-0.045	(-0.156 - 0.076)	0.894
Ssa408	17	0.89	0.88	0.019	(-0.049 - 0.082)	0.157
All Loci		0.76	0.74	0.022*	(-0.012 - 0.046)	0.002

total # individs used = 106

B – Nason Creek wild

Msat Locus	Obs. # Alleles	H_e	H_o	F_{IS} value	95% CI	p-value
Ogo4	11	0.79	0.83	-0.036	(-0.128 - 0.047)	0.824
Ots10M	4	0.53	0.52	0.036	(-0.055 - 0.189)	0.813
Ots211	22	0.94	0.94	0.002	(-0.052 - 0.064)	0.576
Ots213	24	0.90	0.83	0.086*	(0.009 - 0.170)	0.004
Ots2M	6	0.50	0.54	-0.070	(-0.281 - 0.100)	0.460
Oke4	6	0.57	0.45	0.211	(0.018 - 0.373)	0.020
Ots104	33	0.95	0.96	-0.007	(-0.046 - 0.031)	0.550
Ots201b	22	0.92	0.94	0.019	(-0.0172 - 0.038)	0.776
Ots3	5	0.40	0.42	-0.040	(-0.194 - 0.149)	0.279
OtsD9	5	0.72	0.78	-0.077*	(-0.205 - 0.069)	0.001
Ssa408	19	0.88	0.85	0.043	(-0.042 - 0.116)	0.031
All Loci		0.74	0.73	0.012*	(-0.028 - 0.039)	0.002

total # individs used = 85

C – White River Wild

Msat Locus	Obs. # Alleles	H_e	H_o	F_{IS} value	95% CI	p-value
Ogo4	10	0.77	0.79	-0.015	(-0.142 - 0.094)	0.083
Ots10M	3	0.56	0.54	0.048	(-0.145 - 0.250)	0.592
Ots211	24	0.92	0.88	0.052	(-0.029 - 0.122)	0.120
Ots213	20	0.91	0.92	-0.004	(-0.074 - 0.059)	0.021
Ots2M	4	0.54	0.55	-0.015	(-0.228 - 0.178)	0.890
Oke4	6	0.66	0.70	-0.042	(-0.193 - 0.114)	0.588
Ots104	34	0.94	0.94	0.010	(-0.050 - 0.069)	0.022
Ots201b	20	0.93	0.88	0.053	(-0.033 - 0.129)	0.294
Ots3	6	0.55	0.54	0.016	(-0.166 - 0.178)	0.484
OtsD9	6	0.64	0.61	0.066	(-0.100 - 0.205)	0.220
Ssa408	15	0.89	0.86	0.037	(-0.052 - 0.135)	0.503
All Loci		0.76	0.75	0.020	(-0.025 - 0.050)	0.036

total # individs used = 67

Differences among spawning tributaries -- Analyses of population subdivision using F-statistics indicated almost all pair-wise F_{ST} comparisons were significant (Table 5; α=0.05). The sole exception was the comparison between the 2004 wild Chiwawa R. and 1994 Chiwawa R. hatchery Spring-Run populations. Both the LNFH out-planted Spring Chinook as well as the Wenatchee R. Summer Chinook were well differentiated from the wild and hatchery Spring-Run fish (Table 5).

Table 5 -- Matrix of pair-wise F_{ST} (Weir and Cockerham 1984) values for 2004 Wenatchee R. Spring- and Summer-Run fish grouped according to origin (Hatchery vs. Wild). Significance of pair-wise F_{ST} values was assessed by using 1000 bootstrap replicates of an 11 microsatellite dataset. * F_{ST} values statistically significant at $\alpha = 0.05$. Fish identified as summer-run were removed from the dataset prior to analysis. Location was based solely on carcass recovery on tributaries (Chiwawa R., Nason Ck., and White R.).

	Spring-Run								
	Wild			**Chiwawa R. Hatchery**				LNFH	Summer-
Groups	Chiwawa	Nason	Remainder	2 Yr. old	3 Yr. old	4 Yr. old	1994	Outplants	Run
Wild White R.	0.012*	0.017*	0.009*	0.018*	0.013*	0.022*	0.005*	0.012*	0.083*
Wild Chiwawa R.		0.016*	0.001*	0.019*	0.013*	0.008*	0.003	0.016*	0.084*
Wild Nason Crk.			0.009*	0.037*	0.017*	0.018*	0.011*	0.018*	0.091*
Wild Remainder				0.017*	0.010*	0.009*	0.003*	0.012*	0.088*
Hatchery 2 Yr. old					0.023*	0.030*	0.025*	0.019*	0.092*
Hatchery 3 Yr. old						0.013*	0.008*	0.013*	0.084*
Hatchery 4 Yr. old							0.010*	0.021*	0.099*
1994 Chiwawa Hatchery								0.018*	0.110*
LNFH Spring Outplants									0.079*

Combining all 2004 Wenatchee R. hatchery Spring-Run fish into a single group while performing cluster analysis with the Wenatchee R. wild Spring-Run populations, indicated strong bootstrap support for the nodes separating LNFH (100%), and Wenatchee R. hatchery Spring-Run (89%) fish from the wild populations (Figure 1). Moderate bootstrap support (~70%) was obtained for the nodes separating wild populations. A second cluster analysis was performed that included a sample of 1994 Chiwawa R. hatchery Spring Chinook (Figure 2). Wenatchee R. hatchery and wild Spring-Run fish were grouped according to age and carcass recovery location, respectively. The second cluster analysis was based on 8 loci since the 1994 hatchery fish sample had been genotyped at only 8 of 11 loci. Strong bootstrap support (96%) for the node separating LNFH and Wenatchee R. Spring Chinook mirrored that obtained in Figure 1. Moderate bootstrap support (62%) was obtained for the node separating the two year old hatchery fish and the cluster containing all other Wenatchee R. Spring Chinook. Moderate bootstrap support (71%) was obtained for the node separating the cluster of the 4 yr. old hatchery and 2004 Chiwawa R. Wild Spring fish, as was for the node (61%) separating the cluster of the 2004 Nason Creek and remaining wild Spring fish. The 1994 Chiwawa R. Hatchery sample clustered with the 2004-2005 White R. wild Spring fish population, however, boot strap support for this cluster was very low (39%).

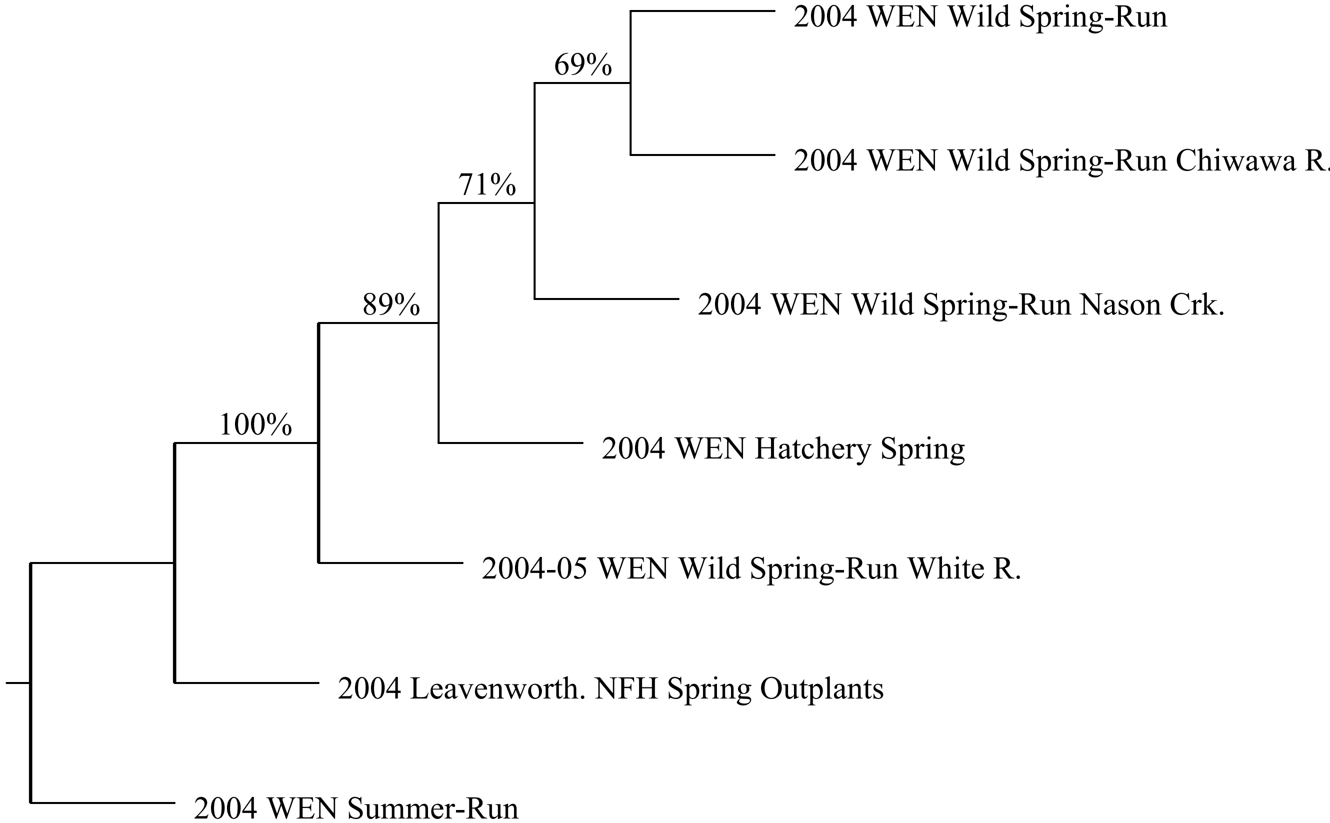

Figure 1-- Unrooted Neighbor-joining phenogram based on Cavalli-Sforza (1967) cord distance units among the 2004 Spring- and Summer-Run Wenatchee R. (WEN) Chinook, and the Spring adults outplanted from Peshastin Creek Hatchery. Note that this unrooted phenogram is merely "re-rooted" by the Summer-Run outgroup. The phenogram was constructed using data from 11 microsatellite loci with PHYLIP (Felsenstein 1989). For 1000 boot-strap replicates, node values of 69% and greater are given. Individuals were grouped as hatchery (CWT, adipose fin-clip, or scale pattern), or wild as well as by carcass recovery location on Chiwawa R., or Nason Crk. Fish identified as Summer-Run were removed prior to constructing the phenogram.

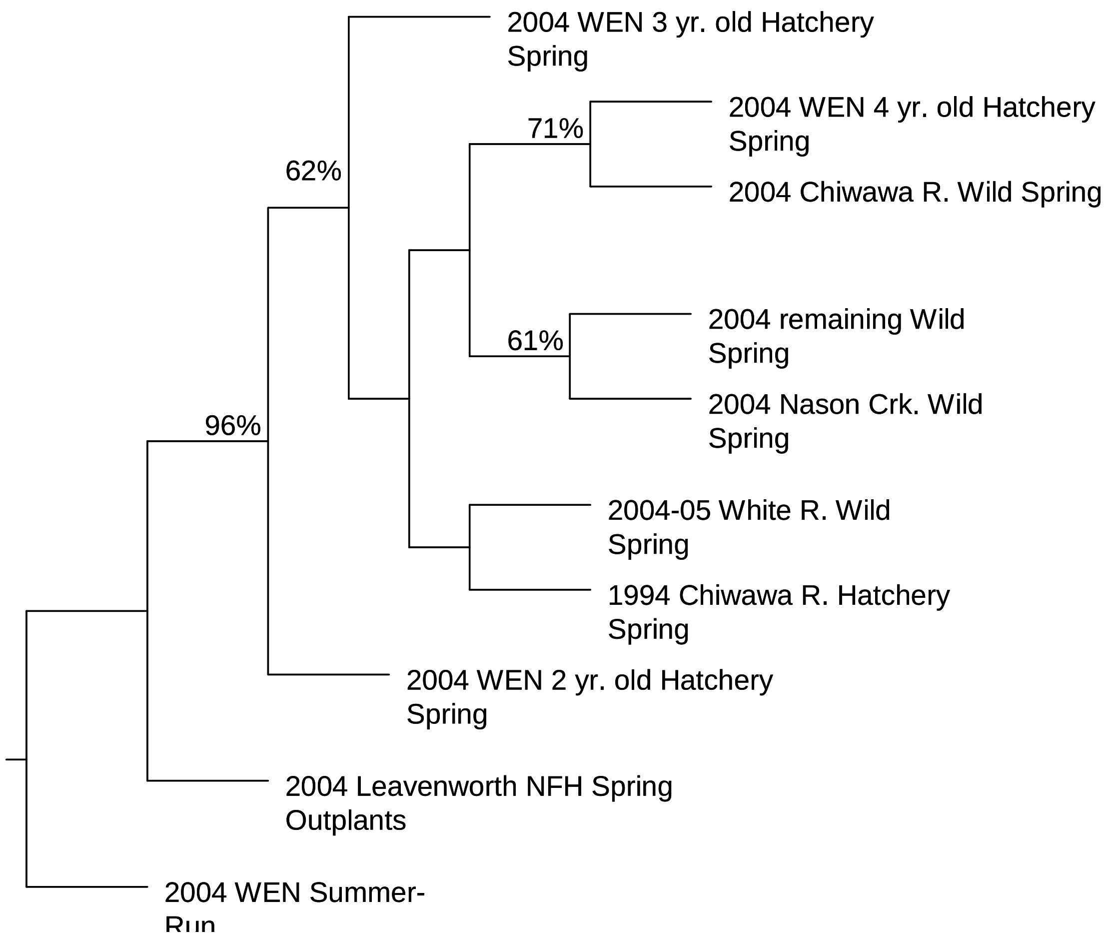

Figure 2 -- Unrooted Neighbor-joining phenogram based on Cavalli-Sforza (1967) cord distance units among the 2004 Spring- and Summer-Run Wenatchee River Chinook, Leavenworth Spring adults out-planted on Peshastin Creek, and 1994 Chiwawa R. Hatchery Spring adults. Note that this unrooted phenogram is merely "re-rooted" by the Summer-Run outgroup. The phenogram was constructed using data from 8 microsatellite loci with PHYLIP (Felsenstein 1989). For 1000 boot-strap replicates, node values of 60% and greater are given. Individuals were grouped as 2, 3 or 4 year old hatchery (CWT, adipose fin-clip, or scale pattern), or wild origin (according to carcass recovery location). Fish identified as Summer-Run were removed from each group prior to constructing the phenogram.

Parentage assignment – Of the 196 Chiwawa River parr genotyped, we attempted to identify parents for the 166 that had complete genotypes (no missing data). The pool of potential parents analyzed consisted of the spring Chinook salmon sampled at Tumwater Dam, except for those fish that were subsequently used for hatchery broodstock. Only potential parents with complete genotypes (no missing data) were used, resulting in 2432 potential parents analyzed out of 2617 total spring Chinook salmon actually on the spawning grounds (i.e., 93% of the potential parents were used in the analysis).

We used the simulation function of the FAMOZ program to determine a critical value, x, for Δ LOD scores such that if only parents with a Δ LOD > x were assigned as "true" parents we would expect no more than 5% of the assignments would be incorrect. When 1000 simulated progeny were generated from the 2432 potential parents, in only 80% of the time was the most likely pair of parents the true pair of parents. In order to limit false assignments to <5%, a Δ LOD criteria of 1.44 was used to screen assignments, which resulted in assignments for only 65% of the simulated progeny.

This low assignment rate was surprising, as earlier simulations and the calculated exclusion probabilities for the loci used in the analysis indicated that >99% of the progeny should have been assigned correctly (see 2005 annual report). We determined that the discrepancy resulted from a difference in how the simulations were performed. The simulations conducted earlier in the study involved first simulating parents from the observed allele frequencies, simulating progeny from the simulated parents, and then testing how well the simulated progeny could be assigned to the simulated parents. This represents an "ideal" case, in that the parents in question were created assuming they were all unrelated and drawn from an infinitely large population. This results in ideal conditions for parentage assignment and therefore high assignment rates. The FAMOZ simulator, in comparison, uses the observed parents themselves to create simulated offspring. Any non-ideal genotypic distributions in the parents are therefore preserved. For example, if the potential parents consist of many close relatives, these relationships will be maintained by the FAMOZ simulations. The parental genotypic distributions are indeed "non-ideal", particularly for hatchery fish (see Table 3), and this apparently accounts for the lower than expected rate of successful assignment.

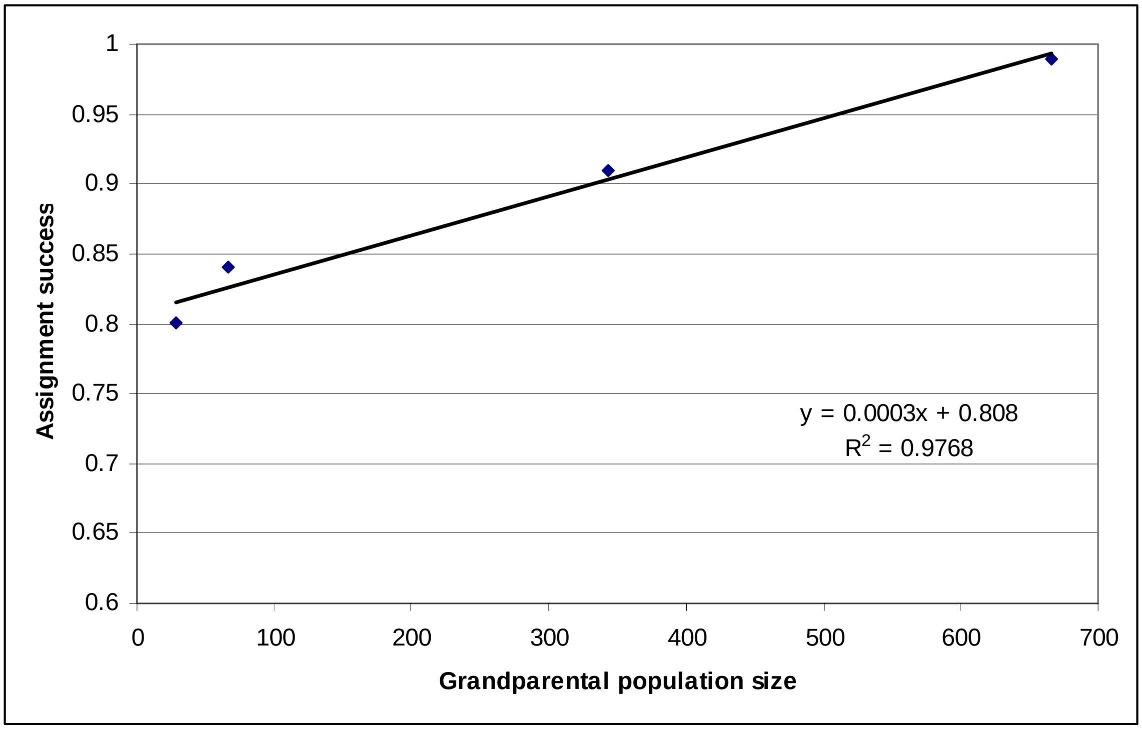

Figure 3 -- Relationship between simulated assignment success rate and the size of the parental populations that produced the spawners returning in 2004 (data from Table 6)

We performed several additional sets of simulations to further examine exactly why the assignment rates were lower than expected. In particular, we wanted to determine if there were differences in assignment rates between hatchery and wild fish. First, we conducted an additional set of simulations (using FAMOZ) for hatchery and wild parents separately. The parents in these simulation consisted of the 840 wild fish in the set of potential parents, and 840 hatchery fish drawn randomly from 1851 total potential hatchery parents. Raw assignment success rates (proportion of time the most likely parent pair was the correct parent pair) for hatchery and wild fish were very different from each other: 82.7% and 97.8% for hatchery and wild fish, respectively. When a Δ LOD criterion was used to limit incorrect assignments to ≤ 5%, the total assignment rate dropped to 66.1% for the hatchery fish.

At present, we do not know why parentage assignment success for hatchery fish is lower than that for wild fish, although the proximate cause is likely to be the greater degree of non-independence among loci (linkage disquilbrium) we observed for hatchery fish compared to wild fish. The high correlations of alleles among loci for hatchery fish mean that, in effect, the hatchery fish are being scored for fewer independent loci than are the wild fish. The degree of linkage disquilibrium in a population is affected by the population's effective population size, such that smaller effective population sizes lead to higher levels of linkage disquilibrium. We found a clear relationship between our statistical ability to assign offspring to parents and the spawning population size of the populations that produced the potential parents (Table 6, Figure 3). Regardless of the cause of the difference in assignment rate between hatchery and wild origin fish, we believe it will be necessary to genotype additional loci in order to increase our rate of successful assignment for progeny of hatchery fish.

Table 6 -- Spawning population sizes for cohorts that produced returns to the natural spawning grounds in 2004

Hatchery origin fish		Parental spawning population size				
Age	Proportion of run in 2004 [3]	Female	Male	Total	Ne [1]	Assignment rate[2]
2	0.36	43	27	70	66	0.84
3	0.43	241	133	374	343	0.91
4	0.20	11	19	30	28	0.80
Natural origin fish		**Parental spawning population size**				
Age	Proportion of run in 2004	Female	Males	Total	Ne	Assignment rate
2	0.00					
3	0.04					
4	0.96	282	406	688	666	0.99

[1] Effective population size (Ne) estimated as 4 (Nmales) (Nfemales) / (Nmales + Nfemales). This estimate of Ne includes only effects of unequal number of males and females. Actual Ne will be smaller due to variance in reproductive success within each sex.
[2] Proportion of simulated assignments in which the most likely parent pair was the true parent pair. Simulations were performed using a random subset of 200 from each age-origin group.
[3] A small number of five year old fish were also present in the run, but not included in this table.

In order to evaluate the effect of adding additional loci, we genotyped 223 of the hatchery fish for an additional four loci, for a total of 15 loci altogether. We then conducted parentage simulations using random subsets drawn from these individuals, with sample sizes ranging from 10 to the full 223. Linear regression was then used to examine the relationship between the number of potential (hatchery) parents and the proportion of correct assignments. From this, we estimate that with 15 loci we would be able to achieve ~90% correct assignments if there ~1800 potential hatchery parents with genotypic distributions like those we observed in 2004 (Figure 4, Figure 5). The difference between hatchery and natural fish in assignment rate continued for the 15 locus set (Table 7).

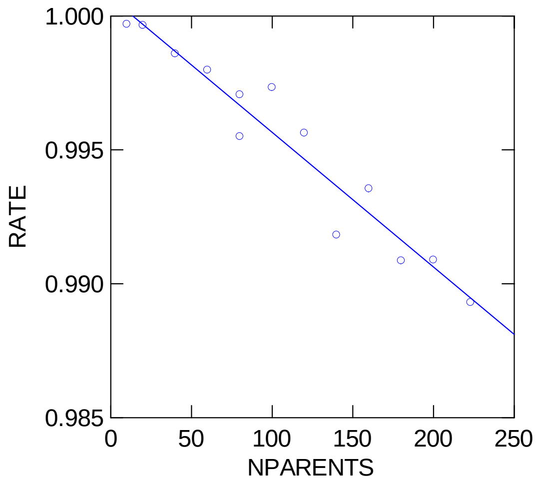

Figure 4 -- Relationship between number of potential parents (hatchery fish only) and the proportion of correct assignments (simulated offspring)

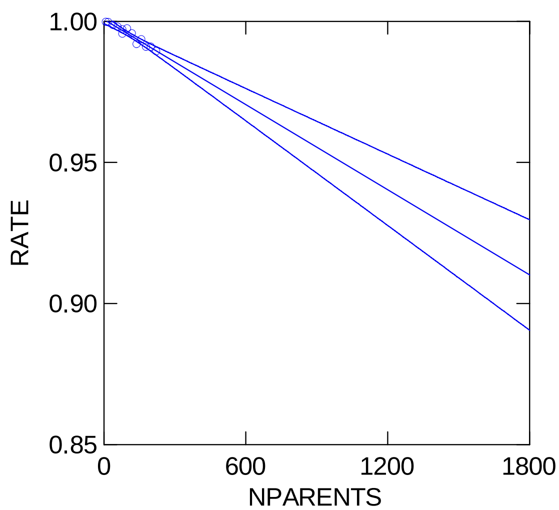

Figure 5 -- Same relationship as plotted in Figure 4, but extrapolated out to 1800 potential parents, with 95% confidence intervals.

Finally, we evaluated the consequences of the difference in assignment rate between hatchery and natural fish to estimation of fitness differences between these two groups. To do this, we used the 2004 Wenatchee spring Chinook parents to simulate 1000 offspring. Offspring were simulated by randomly drawing one male and one female from the parental file and then using Mendelian rules of inheritance (random segregation and independent assortment) to simulate offspring. After offspring were simulated, errors were randomly generated in both the parents at a rate of 1.5% per locus. The resulting data (real potential parents with simulated offspring) were run through the program FAMOZ, which assigns offspring to their most likely parents. After checking the assignments against the known relationships (from the simulations), the assignments were used to generate the mean number of offspring assigned to either hatchery or wild parents, broken down by age and sex. Parents with no progeny assigned were assumed to have zero offspring.

Table 7 -- Parentage assignment success rates for hatchery and wild Wenatchee R. Spring Chinook. * LOD criterion of 1.39 used to limit incorrect assignments to ≤ %5. [R] randomly chosen subset of adults used to make a direct comparison to the 15 microsatellite dataset (Table 1).

# Loci	N	assignment succes rate (%) Hatchery	Wild
11	840	82.7 (66.1)*	97.8
11	223[R]	95.1	99.4
15	223	98.8	--

Using an assignment threshold designed to limit the false assignment rate to ~5%, 715 (71.5%) of the offspring were assigned to a set of parents. This is close to the expected assignment rate of 69% (from the FAMOZ simulations). Of the 715 assignments, 38 (5%) were incorrect when compared against the true relationships. This suggests indicates that the basic assignment algorithm is working as expected.

The mean number of assigned progeny from the simulations differed substantially among age and origin classes (Table 8). For females, the dominant age class for both hatchery and wild fish was 1.2, and within this age class wild fish had significantly more simulated progeny assigned than did hatchery fish. For males, the dominant classes were 1.0, 1.1, and 1.2, and hatchery and wild differed significantly in the age distributions. Within the 1.2 age class, wild fish again had significantly more progeny assignments than did hatchery fish. Within the 1.1 age class, however, wild and hatchery fish did not differ significantly in simulated progeny number. When both the 1.1 and 1.2 age classes were combined, wild fish had a significantly higher progeny numbers assigned. The 1.0 age class is limited to hatchery fish, and had a significantly lower progeny numbers assigned than the wild 1.2 age fish. Based on these results, it appears that the non-random assignment among age and origin groups can lead to the appearance of fitness differences among groups, even though the fitness of the groups is in fact the same because the progeny were simulated without reference to age or origin.

Table 8 -- Simulated and actual fitness estimates (mean progeny numbers) by origin, sex, and age.

Simulated results from 1000 progeny								
Sex	Age	Wild			H/W [1]	Hatchery		
		N	Mean	SD		N	Mean	SD
Male								
	2	0				594	0.30	0.59
	3	27	0.37	0.56	1.08	705	0.40	0.66
	4	387	0.55	0.75	0.55**	90	0.30	0.55
	all	417	0.54	0.74	0.65**	1,415	0.35	0.63
Female	4	346	1.35	1.19	0.70**	236	0.94	1.03

Actual results from 73 Chiwawa assignments									
Sex	Age	Wild			H/W	H/W c[2]	Hatchery		
		N	Mean	SD			N	Mean	SD
Male									
	2	0					594	0.002	0.04
	3	27	0.037	0.19	0.38	0.35	705	0.014	0.13
	4	387	0.121	0.42	1.01	1.85	90	0.122	0.52
	all	417	0.12	0.41	0.13	0.21	1,415	0.016	0.17
Female	4	346	0.15	0.46	0.62	0.89	236	0.093	0.31

[1] Hatchery/wild fitness (mean progeny number of hatchery fish / mean progeny number of wild fish).
[2] Hatchery/wild fitness, corrected by dividing by simulated H/W ratio.
** $p<0.0001$

Of the 166 completely genotyped Chiwawa River parr, we were able to confidently assign 73 (44%) to single pairs of parents. An additional 19 (11%) met the Δ LOD criterion for assignment, but we chose not to assign because they had more than a single incompatible locus. Thirty-five (48%) of the inferred matings involved at least one parent whose carcass was recovered on the Chiwawa River. One inferred mating involved a parent whose carcass was recovered on Nason Creek. The mean number of progeny differed among age and origin classes (Table 8). For males, the parr sample produced far fewer inferred hatchery parents than wild parents. This was entirely due to low progeny numbers for age 2 and 3 fish, age classes which were common for hatchery fish but rare or absent for wild fish (Table 8). After correcting for bias in assignment rates, hatchery females had ~90% as many estimated progeny as wild females (both groups predominantly age 4), and age 4 hatchery males had ~1.8X as many estimated progeny as wild males (Table 8). Note that these results are very preliminary and are unlikely to be statistically meaningful due both to the small number of progeny analyzed and uncertainty about the most appropriate way to analyze the data given the difference in ability to assign parents between the two groups.

We continued to explore the effect of hatchery or wild origin on parental assignment success for the 166 Chiwawa parr. To do this, for each parr, we identified the set of parents whose Δ LOD scores were less than the 5% cutoff criteria. We then divided these groups up into those that contained only potential hatchery parents and those that contained only potential wild parents. For the groups that contained only wild parents, the mean number of likely parents per offspring was 2.15 (Figure 6), suggesting that those progeny that were the products of wildXwild matings were readily assigned to a single set of potential parents. In contrast, in those groups that contained only hatchery parents, the mean number of parents per progeny was 4.07 (Figure 7), suggesting that progeny produced by hatcheryXhatchery matings are more difficult to correctly assign to a single set of parents. These results also suggest the possibility that many of the potential hatchery parents may be close relatives, a hypothesis we are in the process of testing.

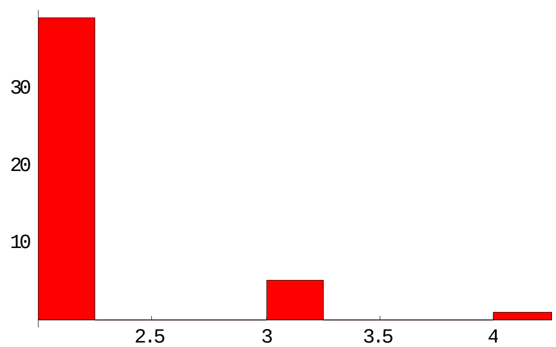

Figure 6 -- Distribution of numbers of high likelihood wild parents

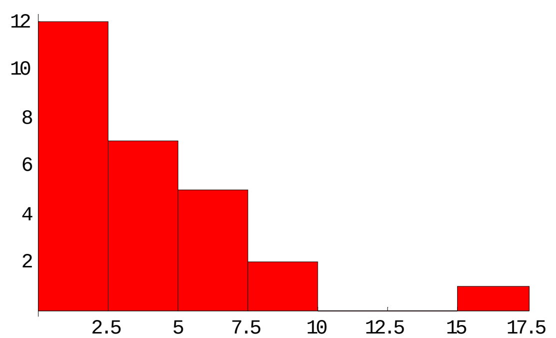

Figure 7 -- Distribution of numbers of high likelihood hatchery parents

Discussion

Population genetic structure appears to exist within Wenatchee R. wild Spring-Run Chinook. In particular, moderate bootstrap support for nodes separating wild populations in the cluster analyses (Figure 1, Figure2) and the low, but statistically significant pair-wise F_{ST} comparisons between all wild populations (Table 5) indicate that there are significant allele frequencies differences between samples from these three tributaries.

Hatchery and wild Spring Chinook also are somewhat genetically distinct from one another. Moderate boot strap support for the node separating two year old hatchery fish from wild fish as well as the separate grouping of the 3 year old hatchery fish (Figure 2) and the low, but statistically significant pair-wise F_{ST} comparisons between hatchery and wild populations (Table 5) indicate a low degree of genetic differentiation between hatchery and wild Spring Chinook.

Interestingly, both pair-wise F_{ST} comparisons (Table 5) and cluster analysis using hatchery fish grouped by age (Figure 2) also indicate varying degrees of genetic differentiation between separate cohorts of hatchery and the wild Spring Chinook. Genetic differentiation between hatchery and wild fish appears to be greater for younger cohorts of hatchery fish (i.e.- two year old hatchery fish are more genetically distinct from the wild populations compared to either the three or four year old hatchery fish).

At a population-level scale there is statistically significant genetic differentiation between the 2004 Wenatchee R. hatchery and wild Spring-Run fish (average $F_{ST} = 0.017$) as well as between those two groups and the LNFH Spring-Run fish out-planted in Peshastin Creek (average $F_{ST} = 0.018$, and 0.015, respectively) (Table 5). However, at the level of the individual, the ability to assign a given spring Chinook of unknown origin to the Wenatchee R. hatchery or wild population was poor (Table 2). Similarly, individual assignment to either the Wenatchee R. or LNFH hatchery baseline populations was poor (Table 2). This reflects the generally low level of genetic distinctiveness of hatchery Spring Chinook within the upper Columbia River Basin (Ford et al. 2001). Individual assignment between spring and summer runs was excellent, however.

An earlier report by Ford et al. (2001) using data collected by WDFW at 44 allozyme loci indicated little evidence of genetic distinctiveness between Chiwawa R. and Nason Creek Spring Chinook. Their Neighbor-Joining phenogram (not shown) of locality by brood year samples based on Nei's unbiased genetic distance (Nei 1987) had, in general, very low bootstrap support for the nodes separating either tributary or for the even and odd brood year Chiwawa R. samples. The only strong support (98%) obtained was for the node separating the White R. populations from all other populations. Within the Wenatchee R. system, contingency analysis (Weir 1996, p. 163) revealed significant differences in allele frequency distributions between only the Chiwawa and White River samples, but not between the 1988 Chiwawa R and Nason Crk. samples. While stray hatchery fish were removed from the previous analyses, the hatchery and wild populations were considered to be effectively part of the same population (Ford et al. 2001). The disparate conclusions reached by this and the previous study are not entirely surprising. First, allozymes are less polymorphic than microsatellites and are less powerful for detecting small differences among populations. Second, the small sample sizes used for Chiwawa River and Nason Creek in the earlier study (average N = 30 and 23, respectively) may have contributed to the inability to resolve their already close genetic relationship. Third, Chiwawa River Hatchery adults stray within the Wenatchee River basin. For instance, in 1997, 33% of the adults sampled on Nason Creek had Chiwawa River Hatchery tags (Ford et al. 2001). Genetic diversity between the two tributaries would be low and thus difficult to detect due to gene flow mediated by stray Chiwawa River hatchery fish.

A large percentage of hatchery and wild Chinook (91% and 76%, respectively) evaluated were not recovered as carcasses on the spawning grounds. Increased capacity to detect passive integrated transponder tagged (PIT-tagged) hatchery and wild adults on the spawning grounds will increase the fraction of fish that can be grouped by tributary. Potential benefits of doing so include increased resolution of genetic distinctiveness within hatchery and wild populations, and increased likelihood of discriminating potential differences in reproductive fitness between hatchery and wild Chinook that are associated with spawning habitat usage within the Wenatchee R. Basin.

Wenatchee R. hatchery Spring Chinook had somewhat different patterns of within-sample variation than were observed for the wild fish samples. The high proportion of microsatellite loci with significantly negative F_{IS} values compared to that expected under HWE (Table 3A) and the very high level of linkage disequilibrium (50 of 55 pair-wise comparisons of loci) for hatchery fish may reflect differences in population size between the hatchery and wild spawning populations in previous years (Figure 3, Table 6).

One surprising result of our initial parentage analysis was the finding that, at least for the 2004 spawners, there was a significant difference in our ability to identify unique pairs of hatchery fish as parents compared to wild fish. The ability to successfully assign fish as parents appears to be correlated with the size of the spawning populations that produced the potential parents in 2004 (Figure 3). The hatchery fish returning in 2004 came from relatively small groups of spawners compared to the wild fish returning in 2004, and this appears to have an influence on our ability to statistically assign offspring to hatchery-origin parents. If this effect is not accounted for, it would seriously bias the estimates of relative fitness of hatchery and wild fish. For example, in simulations in which fitness was expected to be, on average, the same between hatchery and wild fish, our estimates of fitness between the two groups differed significantly due to differences in "assignability" between hatchery and natural fish (Table 8). This effect is also evident in the actual assignments of Chiwawa River parr (Figure 6, Figure 7).

There are two potential ways in which we can approach the problem of differences in parentage assignment rates between hatchery and wild fish. First, we could increase the number of loci scored. Based on the results reported here, we believe we would need to score at least an additional four, and perhaps more, loci in order to bring the successful assignment rate to >95% for hatchery fish. Another potential approach is use partial assignment methods (e.g., Morgan and Conner 2001). These methods assign offspring fractionally to parents in proportion to their likelihoods, and would have the effect of correcting for differences in assignability between groups. The disadvantage of these methods is that they do not actually estimate a single pedigree, so there is no ability track lineages through multiple generations. Our plan is to therefore increase the number of loci scored in order to improve assignment success for hatchery origin fish. We will also continue to explore methods for correcting the bias introduced by differences in assignability.

Even with the 11 locus data set and the very small number of progeny sampled, some differences in fitness between hatchery and natural fish are readily apparent. In particular, the large numbers of age 2 and age 3 hatchery males appeared to have very low fitness based on the current progeny sample (Table 8), a result consistent with the spawning ground observation data (see Chapter 4).

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Chapter 3

Spawning distribution and redd characterization of hatchery and natural origin spring Chinook in the Wenatchee River Basin

Abstract

Spawning ground surveys in the upper Wenatchee River Basin were used to evaluate spawn timing and distribution, redd microhabitat characteristics, and prespawn survival of hatchery and naturally produced fish. In 2005, the composite population of spring Chinook redds were distributed similarly to that of years past. A total of 818 redds were found upstream of Tumwater Dam, of which the female origin was identified on 335 redds. Based on redd counts, the survival of spring Chinook from Tumwater Dam to the spawning grounds was estimated at 42.4%. After correction for carcass recovery bias, no differences were found in the estimated age composition or the proportion of hatchery and natural origin fish of the estimated spawning population compared to population sampled at Tumwater Dam. Hatchery origin fish spawned in significantly lower elevations of the Chiwawa River and Nason Creek than natural origin fish. No difference in spawning timing of hatchery and natural origin spring Chinook was detected. Microhabitat variables were measured on 137 redds, which included 107 and 30 constructed by hatchery and natural origin females, respectively. No differences were found in any of the redd characteristics examined.

Introduction

Hatchery fish may not produce as many progeny as natural fish in natural environments for a variety of reasons. For example, hatchery fish may select inappropriate areas to spawn (e.g., poor water flows or depths), spawn at inappropriate times (Chandler and Bjornn 1988; Leider et al. 1984; Nickelson et al. 1986), construct redds inappropriately (e.g., dig redds that are too shallow to withstand flooding), and die before gametes can be released. Non-representative broodstock selection can skew run timing. Collecting, holding, and spawning salmon broodstock can remove selection pressures (e.g., competing for mates, digging deep redds, maintaining energy stores and other factors) for spawning in the natural environment. Any deviation from naturally produced fish can be assumed to be maladaptive in natural environments.

The reproductive success of hatchery origin fish may be lower than natural origin fish if hatchery origin fish spawn in suboptimal locations. For example, hatchery fish may spawn in unproductive tributaries, portions of tributaries that are suboptimal, or at microhabitats that are suboptimal. If acclimation ponds are located in suboptimal spawning locations and fish home back to these locations, then the reproductive success of hatchery origin fish may be compromised. In short, reproductive success of hatchery origin fish could be compromised even if they are genetically and behaviorally identical to natural origin fish.

The objective of this Chapter is to determine if differences in spawn timing, spawning distribution between and within tributaries, micro site selection, and redd morphologies exist in the upper Wenatchee Basin. Using information collected during spawning ground surveys the relative survival of hatchery and natural origin fish to spawning will be calculated. This information will be used in conjunction with the demographic and genetic data to examine the relative reproductive success of hatchery and natural origin fish spawning naturally in the upper Wenatchee Basin.

Methods and Materials

Spawning ground surveys

All spring Chinook spawning habitat (Mosey and Murphy 2002) in the Upper Wenatchee River (29 rkm), Chiwawa River (49.7 rkm), White River (24.5 rkm), Little Wenatchee River (37.9 rkm) and Nason Creek (24.1 km) was surveyed a minimum of once a week by raft or foot. Rafting was conducted on larger streams (Upper Wenatchee River) or reaches where the flow was too great for foot surveys to be conducted safely (lower Chiwawa River). During periods of peak spawning, one and two person crews surveyed each stream reach a minimum of twice a week. Two or three person crews surveyed reaches, which were selected for redd microhabitat measurements. Historical spring Chinook spawning ground reaches were surveyed to maintain consistency with previous surveys (Appendix C).

When new redds were found, the origin and fork length of the female was determined by live PIT tag detection. Post spawned females guarding redds were scanned for PIT tags using an underwater antenna mounted on an extension handle. Using this technique, we were able to identify an individual fish and correlate the PIT tag with biological data collected at Tumwater Dam. Each redd was assigned a unique GPS waypoint, marked with surveyors flagging attached to nearby vegetation, and recorded in a field notebook. Each flag was labeled with the appropriate reach and redd number, date, redd location, and the surveyor's initials. In addition, a blue flag was used to indicate if the origin of the female was successfully determined. Redd microhabitat variables would later be measured only on completed redds which the female origin was known.

Carcass surveys

Biological data was recorded from all spring Chinook carcasses encountered during spawning ground surveys. Surveys for carcasses continued after spawning was completed until no live fish were observed within the reach. A unique GPS waypoint was assigned to every carcass and the PIT tag code of each carcass was recorded. A genetic tissue sample was collected from those carcasses without a PIT tag (i.e., lost tag before spawning). In addition, the fork and POH length (to the nearest cm), scales, and snouts from all fish were collected. Snouts may contain coded wire tags and due to a low mark rate of age-4 hatchery fish (i.e., not adipose fin clipped) all snouts were collected and the presence of a CWT would be determined at a later date. The number of eggs retained in the body cavity was counted for females with an intact body cavity. Finally, each carcass was mark sampled by removing the caudal fin to prevent double sampling.

Redd microhabitat data

Microhabitat characteristics of redds were measured in selected reaches of the Chiwawa River and Nason Creek. Based on data collected in 2004, these reaches were selected because of the greater probability that hatchery and natural origin redds would be created in these reaches. Microhabitat characteristics were measured for redds of known female origin. The maximum length and width of the redd was recorded to the nearest 0.1 m. Water depth measurements (nearest cm) were taken at the upstream side of the bowl, the deepest point within the bowl, the upstream side of the tail, the shallowest point of the tail, the downstream side of the tail, and left and right side of the redd (Figure 1).

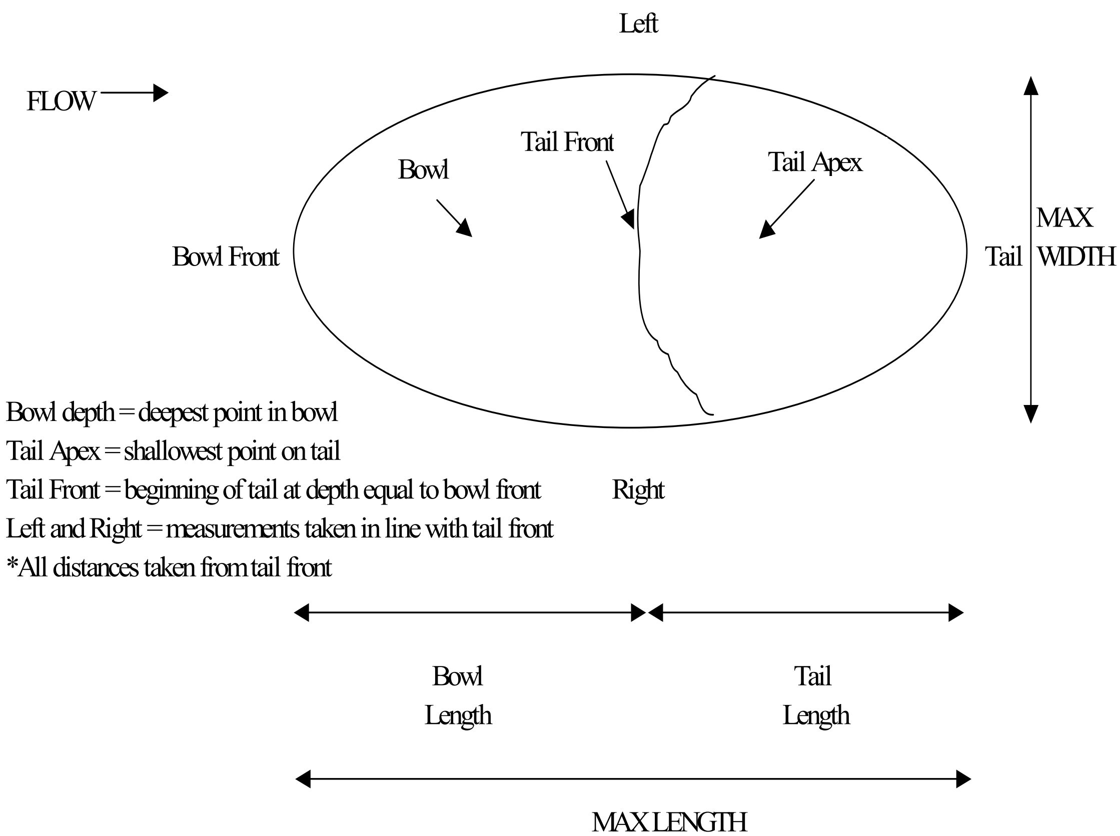

Figure 1. Locations of redd microhabitat characteristic measurements.

Water velocity (m/s) was measured using a Marsh McBirney Model 2000 or Swoffer Model 2100 flow meter. Water velocity was recorded at the upstream side of the bowl (60% depth), maximum depth of the bowl (60% depth), upstream side of the tail (60% depth, surface, bottom), downstream side of the tail (60% depth), and the left and right side of the redd (60% depth). Average redd water depth was the calculated from water depth measurements recorded at the left and right side of the redd and the upstream side of the bowl. Bowl depth was calculated by subtracting the average depth from the maximum depth of the bowl. Average tail depth was calculated by subtracting the depth at the tail apex for the average depth measured on the right and left side of the redd. The distance to the nearest redd (m) and nearest cover type (i.e., riffle, pool, large woody debris, boulder, vegetation or bank) was also measured. Substrate composition (i.e., sand, gravel, cobble, or boulder) was visually estimated for the bowl and tail. Temperature (C°) was also recorded during microhabitat measurements or later downloaded from temperature probes.

Data Analysis

Non-parametric statistical tests were used when assumptions of parametric tests could not be met. A Chi-square test was used to test for any differences in prespawn mortality of hatchery and naturally produced spring Chinook by comparing the proportion of hatchery and naturally produced fish observed at Tumwater Dam to the spawning population. A Chi-square test was also used to examine the age compositions of hatchery and natural fish at Tumwater Dam and spawning grounds.

Hatchery fish destined for the spawning grounds upstream of Tumwater Dam should return to the Chiwawa River. Unfortunately, freezing conditions in the Chiwawa River during the winter force the use of Wenatchee River water at the Chiwawa acclimation ponds during the month of December through February. As a result, returning adults have poor homing fidelity and spawn throughout the basin. Spawning distribution of hatchery and natural origin spring Chinook was analyzed using carcass recovery location (rkm) as the dependent variable. Differences in the spatial distribution of hatchery and naturally produced fish recovered on the spawning grounds were tested using a Kruskal-Wallis ANOVA (KW). Significant differences in spawning distribution were analyzed using a multiple comparison of ranks test to determine the source of differences.

Based on historical data, specific reaches were selected in both the Chiwawa River and Nason Creek that had the highest probability of containing the greatest number of both hatchery and natural origin spawners. Data collected from these reaches were used in the analysis of spawn timing and redd microhabitat. Spawning timing was assessed at the hatchery during routine spawning operations and on the spawning grounds. A KW test was used to compare the spawn timing of hatchery and natural origin female spring Chinook for both redds and carcasses because statistical assumptions of data normality and equal variances could not be met. Relationships between run timing and spawn timing were examined with a Pearson Product moment correlation statistic.

Microhabitat characteristics of redds constructed by hatchery and natural origin fish were compared using ANOVA. Several variables (i.e., redd depth, bowl front depth, redd area, bowl length and female fork length) were log-transformed to meet assumptions of data normality and equal variances. Correlation analysis was performed to examine the relationship between fish size and redd microhabitat characteristics. All statistical tests were performed at a significance level (α) of 0.05.

Spawning Ground Surveys

Chiwawa River

A total of 332 redds were found in the Chiwawa River basin in 2005. Of those redds, 330 redds (99.4%) were found in the Chiwawa River, while only 2 redds (0.60%) were found in tributaries (i.e., Chikamin and Rock creeks). Redds were constructed first in the higher elevation reaches and progressively downstream as the spawning season ended (Table 1). Spawning began the first week of August and continued until third week of September, with peak spawning occurring during the fourth week of August (Appendix B). The origin of the female constructing the redd was determined for 117 redds (35.2%). Of which, 92 redds were hatchery and 25 redds were naturally produced.

Table 1. Number of spring Chinook redds located within historical reaches during spawning ground surveys on the Chiwawa River in 2004 and 2005.

Survey Week	Historical Reach (rkm)						Totals redds
	0-20	20-32	32-37	37-43	43-45	45-51	
				2004			
07/25	0	0	0	0	0	0	0
08/01	0	3	2	0	0	3	8
08/08	0	20	2	14	1	0	37
08/15	2	10	1	10	4	0	27
08/22	1	33	1	11	11	10	67
08/29	10	40	0	12	5	6	73
09/05	19	5	0	1	0	0	25
09/12	4	0	0	0	0	0	4
09/19	0	0	0	0	0	0	0
09/26	0	0	0	0	0	0	0
Total	36	111	6	48	21	19	241
				2005			
07/31	0	0	0	0	0	0	0
08/07	0	1	0	1	2	1	5
08/14	0	7	0	7	4	5	23
08/21	2	34	1	6	5	8	56
08/28	19	80	5	15	5	5	129
09/04	18	42	1	6	1	2	70
09/11	15	12	0	0	0	0	27
09/18	21	1	0	0	0	0	22
09/25	0	0	0	0	0	0	0
Total	75	177	7	35	17	21	332

Nason Creek

During surveys on Nason Creek a total 193 redds were found in 2005. The temporal distribution of redds was similar to that observed on the Chiwawa River. Spawning began earliest in the uppermost reaches and progressively downstream later (Table 2). Spawning activity began during the fourth week of July and continued until the third week of September, with peak spawning occurring in the second week of September (Appendix B). The origin of the female constructing the redd was determined for 106 redds (54.9%). Of those redds, 82 were hatchery and 24 were naturally produced.

Table 2. Number of spring Chinook redds located within historical reaches during spawning ground surveys on Nason Creek in 2004 and 2005.

Week	Historical reach (km)				Total redds
	0-7	7-14	14-22	22-26	
			2004		
07/25	0	0	0	0	0
08/01	0	0	0	2	2
08/08	0	0	2	2	4
08/15	0	0	8	6	14
08/22	0	1	7	5	13
08/29	5	11	31	13	60
09/05	35	16	1	0	52
09/12	10	2	0	0	12
09/19	3	4	5	0	12
09/26	0	0	0	0	0
Total	53	34	54	28	169
			2005		
07/31	0	0	0	1	1
08/07	0	0	0	1	1
08/14	0	0	1	0	1
08/21	0	0	5	6	11
08/28	4	3	18	6	31
09/04	32	17	13	4	66
09/11	71	3	0	0	74
09/18	1	7	0	0	8
09/25	0	0	0	0	0
Total	108	30	37	18	193

Upper Wenatchee River

A total of 143 redds were located by raft or on foot on the upper Wenatchee River in 2005. Only the two highest elevation reaches were surveyed based on historical spring Chinook spawning ground surveys. The temporal distribution of redds was confined to the upper most reach, with no redds found in the lower reach (Table 3). Spawning began the fourth week of August and continued until the third week of September, with peak spawning occurring during the third week of September (Appendix B). Female origin was determined for 6 redds (4.2%). Of those redds, all were constructed by hatchery females.

Table 3. Number of spring Chinook redds located within historical reaches during spawning ground surveys on the Wenatchee River in 2004 and 2005.

Survey Week	Historical Reach (rkm)		Totals Redds
	59-81	81-90	
		2004	
08/22	0	0	0
08/29	0	0	0
09/05	0	11	11
09/12	0	26	26
09/19	1	8	9
09/26	0	0	0
Total	1	45	46
		2005	
08/21	0	0	0
08/28	0	1	1
09/04	0	34	34
09/11	0	20	20
09/18	0	88	88
09/25	0	0	0
Total	0	143	143

White River

Survey crews found a total of 86 redds in the White River basin in 2005. Of those, 83 redds (96.5%) were found in the White River, while 3 redds (3.5%) were found in the Napeequa River. Redds were distributed primarily in the mid elevation reach (Table 4). Spawning activity started during the second week of August and continued until the third week of September, with peak spawning occurring in the fourth week of August

(Appendix B). The origin of the female was determined for 71 redds (82.6%). Of the redds in which origin was determined, 55 were hatchery and 16 were naturally produced.

Table 4. Number of spring Chinook redds found within historical reaches during spawning ground surveys on the White River in 2004 and 2005. Three redds were found between rkm 11- 18 in the Napeaqua River in 2005.

Survey	Historical Reach (rkm)			Totals
Week	11-18	18-22	22-24	redds
		2004		
08/08	0	0	0	0
08/15	0	0	0	0
08/22	0	5	0	5
08/29	0	5	0	5
09/05	0	7	1	8
09/12	0	3	1	4
09/19	0	0	0	0
09/26	0	0	0	0
Total	0	20	2	22
		2005		
07/31	0	0	0	0
08/07	0	0	0	0
08/14	0	1	0	1
08/21	0	14	1	15
08/28	3	33	0	36
09/04	3	13	0	16
09/11	2	15	0	17
09/18	0	1	0	0
09/25	0	0	0	1
Total	8	77	1	86

Little Wenatchee River

A total of 64 redds were found during spawning on the Little Wenatchee River in 2005. The temporal distribution of redds began at the higher elevation reach and progressed into the lower reach (Table 5). Active spawning began the second week of August and continued until the third week of September, with peak spawning occurring during the fourth week of August (Appendix B). Female origin was determined for 35 redds (54.7%). Of those redds, it was determined that 23 were hatchery and 12 were naturally produced.

Table 5. Number of spring Chinook redds located within historical reaches during spawning ground surveys on the Little Wenatchee River in 2004 and 2005.

Survey Week	Historical Reach (rkm)			Totals redds
	5-9	9-15	15-21	
		2004		
08/08	0	0	0	0
08/15	0	4	0	4
08/22	0	2	0	2
08/29	1	4	0	5
09/05	1	1	0	2
09/12	0	0	0	0
09/19	0	0	0	0
09/26	0	0	0	0
Total	2	11	0	13
		2005		
07/31	0	0	0	0
08/07	0	0	0	0
08/14	0	1	0	1
08/21	0	3	0	3
08/28	10	10	0	23
09/04	7	14	0	21
09/11	7	8	0	12
09/18	1	3	0	4
09/25	0	0	0	0
Total	25	39	0	64

Carcass Surveys

Chiwawa River

Of the 391 carcasses sampled throughout the Chiwawa River basin in 2005, scale analysis determined the proportion of hatchery and naturally produced fish was 83% (N = 321) and 17% (N = 64), respectively. Based on a male to female ratio derived from the broodstock of 0.8 to 1 (i.e., 1.8 fish per redd), spawning escapement was estimated to be 496 hatchery and 102 naturally produced fish. All snouts were collected and sent to the WDFW CWT lab in Olympia to determine if CWTs were present and then decoded. The abundance of hatchery carcasses was highest in the lowest reach (rkm 0.0-20.0), which was near the acclimation pond, while the naturally produced carcass distribution was more similar to the redd distribution (Table 6). Presumably, the higher abundance of hatchery fish in the lower reaches was influenced by the location of the acclimation pond (See Spawning Distribution).

Table 6. Proportion of redds and carcasses by reach in the Chiwawa River in 2004 and 2005.

River (km)	2004				2005			
	Redds	Carcasses			Redds	Carcasses		
		Hatchery	Natural	Total		Hatchery	Natural	Total
0-20.0	0.15	0.27	0.14	0.41	0.23	0.44	0.04	0.48
20.0-32.0	0.46	0.13	0.29	0.41	0.53	0.34	0.09	0.43
32.0-37.0	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.03
37.0-43.0	0.20	0.00	0.07	0.07	0.11	0.02	0.01	0.03
43.0-45.0	0.09	0.01	0.04	0.05	0.05	0.01	0.01	0.02
45.0-51.0	0.08	0.02	0.02	0.04	0.06	0.01	0.01	0.01

Nason Creek

A total of 217 carcasses were recovered in Nason Creek during 2005. Scale analysis determined the proportion of hatchery and naturally produced fish was 81% (*N* =172) and 19% (*N* = 40), respectively. All carcass snouts were collected and sent to the WDFW CWT lab to extract and decode potential CWTs. All hatchery fish in Nason Creek were considered strays because hatchery programs are currently not releasing fish into Nason Creek. An estimated 281 hatchery and 66 naturally produced fish spawned in Nason Creek during 2005. The largest proportion of hatchery carcasses were recovered in the lowest reach, while naturally produced carcasses were more evenly distributed (Table 7).

Table 7. Proportion of redds and carcasses by reach in the Nason Creek in 2004 and 2005.

River (km)	2004				2005			
	Redds	Carcasses			Redds	Carcasses		
		Hatchery	Natural	Total		Hatchery	Natural	Total
0-7.0	0.31	0.22	0.15	0.37	0.56	0.61	0.08	0.69
7.0-14.0	0.20	0.13	0.19	0.32	0.16	0.08	0.02	0.10
14.0-22.0	0.32	0.06	0.10	0.16	0.19	0.10	0.05	0.16
22.0-26.0	0.17	0.02	0.13	0.15	0.09	0.02	0.03	0.05

Upper Wenatchee River

In the upper Wenatchee River a total of 120 carcasses were recovered during spawning ground surveys in 2005. Scale analysis determined the proportion of hatchery and natural origin fish recovered was 97% (*N* = 113) and 3% (*N* = 3), respectively. All snouts potentially containing CWTs were recovered and sent to the WDFW CWT lab in Olympia to be extracted and decoded. The number and composition of the spawning population was estimated at 249 hatchery and 8 natural origin fish. Carcass distribution of both hatchery and naturally produced fish was similar to redd distribution (Table 8).

Table 8. Proportion of redds and carcasses by reach in the Upper Wenatchee River in 2004 and 2005.

River (km)	2004				2005			
	Redds	Carcasses			Redds	Carcasses		
		Hatchery	Natural	Total		Hatchery	Natural	Total
60.0-81.0	0.02	0.00	0.06	0.06	0.00	0.03	0.00	0.03
81.0-90.0	0.98	0.67	0.28	0.94	1.00	0.95	0.03	0.97

White River

Of the 52 carcasses recovered in the White River during 2005, scale analysis determined the proportion of hatchery and natural origin fish was 78% (*N*=38) and 22% (*N*=11) respectively. All carcass snouts were collected and sent to the WDFW CWT lab to extract and decode potential CWTs. Spawning ground surveys in the White River were conducted at a greater frequency (twice a week) in collaboration with a captive broodstock program funded by Grant County PUD. As a result, the proportion of unique PIT tag recaptures (*N* = 102; 66%) was greater than the number of carcasses recovered (34%). Based on the proportion of hatchery (69%) and natural fish (31%) detected on the spawning grounds, the number of fish on the spawning grounds was 107 and 48, respectively. Hatchery carcass distribution occurred primarily within the reach where a majority of the redds were located (Table 9).

Table 9. Proportion of redds and carcasses by reach in the White River in 2004 and 2005.

River (km)	2004				2005			
	Redds	Carcasses			Redds	Carcasses		
		Hatchery	Natural	Total		Hatchery	Natural	Total
11.0-18.0	0.00	0.00	0.10	0.10	0.09	0.06	0.02	0.08
18.0-22.0	0.91	0.10	0.80	0.90	0.90	0.71	0.20	0.92
22.0-24.0	0.09	0.00	0.00	0.00	0.01	0.00	0.00	0.00

Little Wenatchee River

Of the 48 carcasses recovered in the Little Wenatchee River during 2005, scale analysis indicated that the proportion of hatchery and natural origin fish was 64% (N=30) and 36% (N=17), respectively (Table 10). The estimated spawning population was 74 and 41 hatchery and naturally produced fish, respectively.

Table 10. Proportion of redds and carcasses by reach in the Little Wenatchee River in 2004 and 2005.

River (km)	2004				2005			
	Redds	Carcasses			Redds	Carcasses		
		Hatchery	Natural	Total		Hatchery	Natural	Total
5.0-9.0	0.15	0.00	0.00	0.00	0.39	0.21	0.09	0.30
9.0-15.0	0.85	0.00	1.00	1.00	0.61	0.43	0.28	0.70
15.0-21.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PIT Tag Retention and Detectability

PIT tag retention by adult spring Chinook was higher than in 2005 (93%) than observed in 2004 (85%). Additional training on proper technique and placement conducted early in the field season likely contributed to the higher retention rates. In 2005, both 20 mm and 12 mm PIT tags were inserted in adults, while only 12 mm PIT tag were inserted into jacks and precocious males. Larger PIT tags should result in higher detections rates on the spawning grounds, however potentially lower retention rates may negate any potential benefits. The 20 mm and 12 mm PIT tags were inserted in adult spring Chinook systematically throughout the run (i.e., every 25 fish) in order to compare detection and retention rates on the spawning grounds. No difference was detected in detection rates on the spawning grounds between the 20 mm and 12 mm PIT tags (χ^2 = 2.83, df = 1, P = 0.09). Furthermore, no difference in PIT tag retention was detected in either age-4 (χ^2 = 0.20, df = 1, P = 0.65) or age-5 (χ^2 = 0.005, df = 1, P = 0.79) spring Chinook. New generation 12 mm PIT tag are now available that have a greater range in detection and should result in a higher detection rate on the spawning grounds.

Spring Chinook Spawning Ground Surveys Downstream of Tumwater Dam

Spring Chinook spawn in limited numbers downstream of Tumwater Dam. Smolts produced from Peshastin Creek and the Icicle River may be captured during smolt sampling in 2006. Therefore, it is important to include potential production from these streams in the future sampling designs. Chelan County Public Utility District (CCPUD) personnel conducted the spawning ground surveys and sampled carcasses recovered during surveys using similar methodologies previously described.

Icicle Creek

A total of 8 redds were found during spawning ground surveys in 2005. Historically, fish recovered on the Icicle River originate from the Leavenworth National Fish Hatchery (LNFH), which is also located on the Icicle River. Of the 2 carcasses sampled, scale analysis determined that both were hatchery origin (100%). The spawning population was estimated at 14 hatchery fish. Of the hatchery fish sampled, one snout containing a CWT was sent to the WDFW CWT lab in Olympia to be extracted and decoded.

Peshastin Creek

CCPUD personnel found 3 redds in Peshastin Creek and Ingalls Creek. However, no carcasses were recovered in 2005. No hatchery adults were expected to return to Peshastin Creek in 2005 (i.e., no hatchery releases). Therefore, the spawning population was assumed to be natural origin fish (N = 5).

Spawning Ground Summary

Composition of fish on the spawning grounds for each stream was calculated based on the number of redds multiplied by the fish per redd values. The proportion of hatchery and natural origin fish was calculated by multiplying the proportion of carcasses recovered within each reach. The composition of the spawning population upstream of Tumwater Dam was 80% hatchery and 20% naturally produced (Table 11). Sampling at Tumwater Dam indicated the proportion of hatchery and natural origin fish available for spawning upstream of Tumwater Dam was 87% and 13%, respectively. The estimated composition of the spawning population upstream of Tumwater Dam was significantly different than the population sampled at Tumwater Dam (χ^2 = 11.53, df = 1, P<0.001). In 2005, 99% of the spring Chinook redds were found upstream of Tumwater Dam. Based on the number of potential spawners at Tumwater Dam (N = 3,475) and the estimated spawning population, the survival to spawning was 42.4% (Table 11).

Table 11. Number of redds, proportion of population recovered as carcasses, and the estimated number of hatchery and natural origin fish, based on scale samples from carcasses or PIT tag recaptures that spawned in the upper Wenatchee River Basin in 2004 and 2005.

River	Number of redds	Sample Rate	Number of fish		
			Hatchery	Natural	Total
		2004			
		Upper Wenatchee Basin			
Chiwawa	241	0.2086	371	487	858
Nason	169	0.3669	217	290	507
Little Wenatchee	13	0.0256	0	39	39
White	22	0.1969	7	59	66
Wenatchee	46	0.1667	97	41	138
Subtotal	491		692	916	1,608
		Lower Wenatchee Basin			
Icicle	30	0.2963	50	4	54
Peshastin	55	0.4590	99	0	99
Subtotal	94		149	4	153
Wenatchee Basin Total	585		841	920	1,761
		2005			
		Upper Wenatchee Basin			
Chiwawa	332	0.6109	463	135	598
Nason	193	0.6182	270	78	348
Little Wenatchee	64	0.4138	75	41	116
White	86	0.3333	119	34	153
Wenatchee	143	0.4615	251	7	258
Subtotal	818		1,178	295	1,473
		Lower Wenatchee Basin			
Icicle	8	0.1429	14	0	14
Peshastin	3	0.0000	0	5	5
Subtotal	11		14	5	19
Wenatchee Basin Total	829		1,221	270	1,491

Differences in the expected and observed composition of spawners may be attributed to either differential mortality or biases in the carcasses recovered on the spawning grounds. Carcasses were recovered in similar proportions to the spawning populations (See Carcass Recovery Section in this Chapter). The age composition of the hatchery and natural spring Chinook was different (See Chapter 1). If age composition of hatchery and natural fish is different and carcass recovery probability unequal, the estimated proportion of hatchery and natural fish on the spawning grounds would be biased towards the group of fish with the greater proportion of larger or older fish. Zhou (2002) reported that the probability of carcass recovery was size dependent and the abundance of smaller fish (i.e., age-3) was negatively biased by 21.1% and larger fish (i.e., age-5) was positively biased by 16.2%. In that study age-4 fish, the dominant age class in the Wenatchee Basin, was positively biased only 1.4%. These results support the observed differences in age distribution between Tumwater Dam and carcasses recovered on the spawning ground.

In the Wenatchee Basin, the proportion of carcasses recovered in each age class was also size dependent (i.e., age-2 = 0.0; age-3 = 0.182; age-4 = 0.438; age-5 = 0.495) and the expected and observed age composition of carcasses recovered on the spawning grounds was significantly different than that observed at Tumwater Dam ($\chi^2 = 149.6$, df = 3, $P < 0.001$). Excluding age-2 fish from the analysis (i.e., recovery probability of age-2 fish was zero) did not influence the results ($\chi^2 = 21.2$, df = 2, $P < 0.001$). The mean carcass recovery probability was calculated using the formula provided in Zhou (2002), except the length measurement used was post-orbital to hypural plate (POH) instead of mid-eye to posterior scale (MEPS). Because carcass recovery probabilities were calculated for each age class and not individual fish, the difference in POH and MEPS should not affect the results. The estimated age composition of the spawning population was calculated by dividing the number of carcasses by the mean recovery probability (Table 12). No difference was found between the age composition of fish at Tumwater Dam and the estimated age composition of hatchery spawners ($\chi^2 = 5.3$, df = 2, $P = 0.07$), natural origin spawners ($\chi^2 = 2.4$, df = 2, $P = 0.30$), or when combined ($\chi^2 = 1.2$, df = 2, $P = 0.56$). These results suggest that there is no differential survival of hatchery and natural origin fish from Tumwater Dam to the spawning grounds. However, mortality may be quite high between the time that fish are sampled at Tumwater Dam and when spawning occurs.

Table 12. Age composition of spring Chinook at Tumwater Dam destined for the spawning grounds and the age composition of the carcasses recovered from the spawning grounds. The estimated proportion of fish on the spawning grounds was calculated from the number of carcasses recovered and the recovery probability.

	Tumwater Dam		Carcasses		Recovery Probability	Estimated Proportion
	N	%	*N*	%		
			2004			
Age-3	771	0.412	92	0.245	0.064	0.434
Age-4	1,086	0.581	279	0.744	0.150	0.561
Age-5	13	0.007	4	0.011	0.218	0.006
			2005			
Age-3	137	0.040	25	0.017	0.063	0.043
Age-4	3,200	0.933	1,401	0.952	0.161	0.934
Age-5	93	0.027	46	0.031	0.213	0.023

Spawning Distribution

Differences were detected in the distribution of hatchery and natural origin female spring Chinook in both the Chiwawa River (Figure 2; df = 3, H = 26.3, $P < 0.001$) and Nason Creek (Figure 3; df = 3, H = 24.5, $P < 0.001$). The spawning distribution of both male and female hatchery spring Chinook was more constrained than that of natural origin fish. Natural origin male spring Chinook exhibited the greatest distribution of all groups. Natural origin female spring Chinook spawned with a greater proportion of natural origin spring Chinook. No differences in spawning distribution were found in the Little Wenatchee River or White River, probably due to the limited length of stream with suitable spawning habitat. The spawning distribution in the upper Wenatchee River was not analyzed because only three natural origin carcasses (2.7% of the estimated spawning population) were recovered.

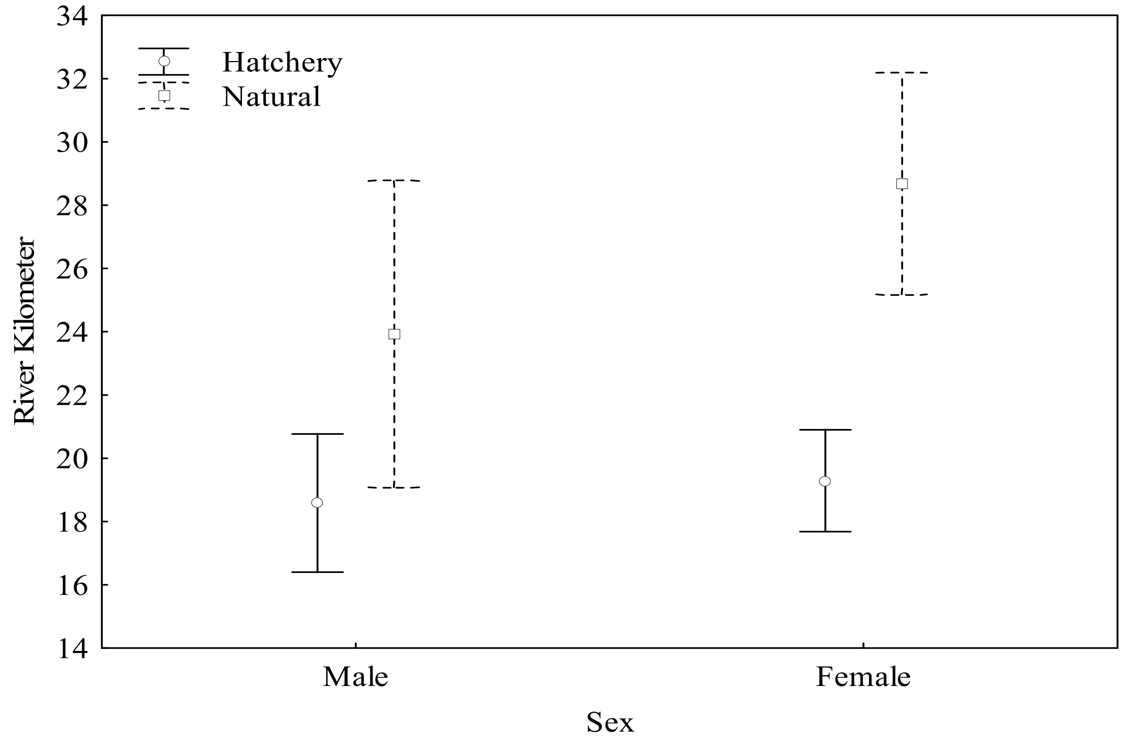

Figure 2. Mean carcass recovery locations of hatchery and natural origin spring Chinook in the Chiwawa River in 2005. Vertical bars denote 95% confidence intervals.

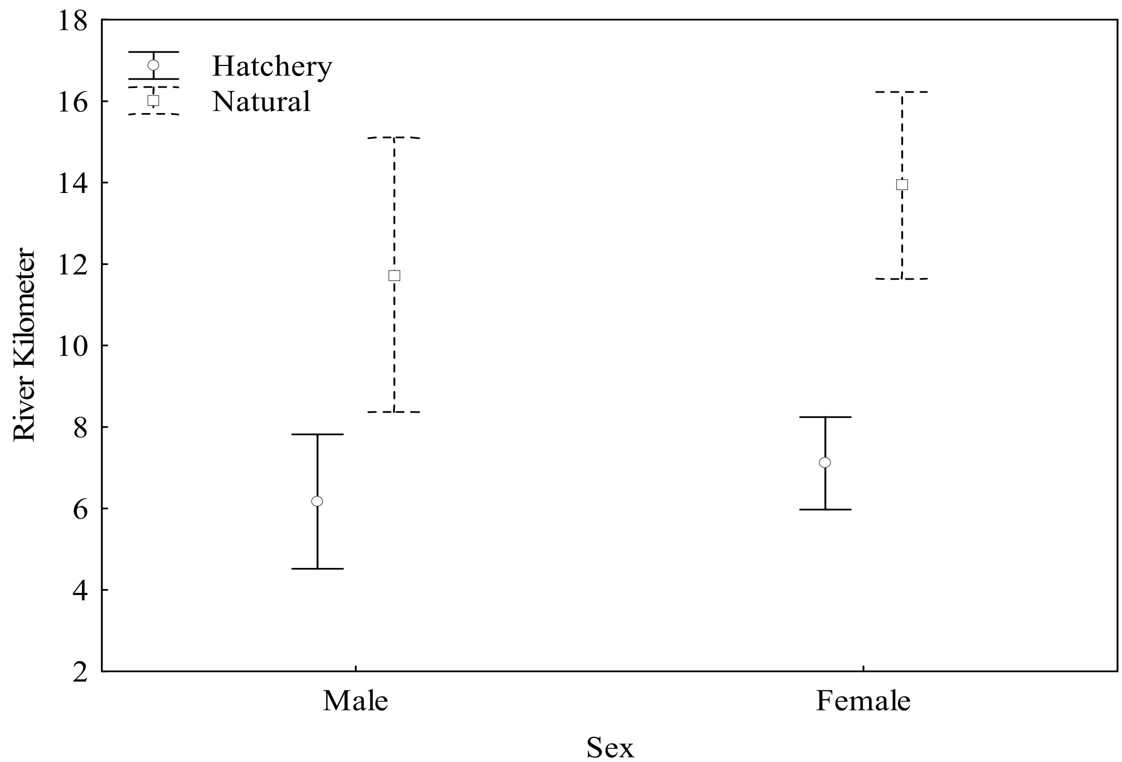

Figure 3. Mean carcass recovery locations of hatchery and natural origin spring Chinook in the Nason Creek in 2005. Vertical bars denote 95% confidence intervals.

Spawn Timing

Passage timing and spawning timing for hatchery and natural origin fish collected as broodstock were not significantly correlated for hatchery ($r = 0.01$, $P > 0.05$) or natural origin fish ($r = 0.11$, $P > 0.05$). A similar lack of correlation between passage and spawn timing was also reported in the Yakima Basin (Knudsen et al. In Press). During spawning at the hatchery, no difference in spawn timing was detected between hatchery and natural origin fish (two sample t-test, t = 1.28, df = 122, $P = 0.20$).

Passage date at Tumwater Dam and the spawn date of the female that was observed spawning (See Redd Microhabitat Characteristics) was also not significantly correlated ($r = 0.03$, $P = 0.85$). Spawning in the natural environment begins at the higher elevations and progresses to lower elevations (See this Chapter). Spawn timing on the spawning grounds was assessed using the date redds were constructed and the date carcasses were recovered (females only). As previously discussed, the spatial distribution of hatchery and natural origin fish in the Chiwawa River and Nason Creek were different. The difference in spatial distribution and subsequently the elevation of spawning locations required that the influence of elevation be controlled in the analysis. The same reaches used in the redd microhabitat analysis (Chiwawa N = 1; Nason N = 2) were used to test for differences in spawn timing (Table 13).

No difference in spawn timing ($P > 0.05$) was detected within reaches using either redds (Figure 4) or carcasses (Figure 5). However, differences were detected between reaches ($P < 0.05$). Differences between reaches were attributed to significant differences ($P < 0.01$) in elevation between reaches. Knudsen et al. (2005) reported that Yakima hatchery spring Chinook spawned earlier at the hatchery, but using carcasses recovered on the spawning grounds no consistent difference was found.

Table 13. Summary of spawn timing analysis for spawning clusters in the Chiwawa River and Nason Creek in 2004 and 2005.

Stream/method	Spawning cluster elevation (m)		Sample size	
	Lower	Upper	Hatchery	Natural
		2004		
Chiwawa/Redds	729	739	13	17
	775	814	16	80
Chiwawa/Carcass	607	610	16	7
	668	673	15	4
	727	737	27	40
	775	804	11	40
Nason/Redds	606	613	13	22
	665	686	8	41
Nason/Carcass	605	615	45	36
	663	680	27	40
	730	746	3	23
		2005		
Chiwawa/Redds	660	810	48	14
Chiwawa/Carcass	711	810	87	27
Nason/Redds	566	618	51	5
	630	684	14	8
Nason/Carcass	564	622	69	10
	635	694	13	9

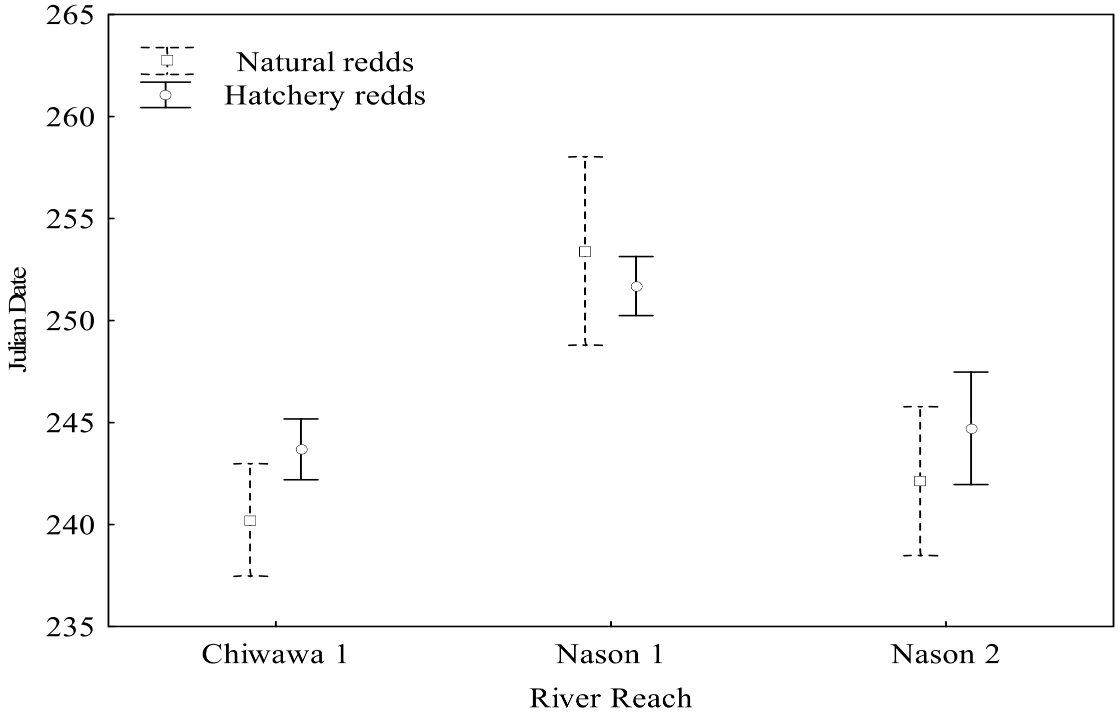

Figure 4. Mean date redds were constructed by female hatchery and natural origin spring Chinook fish spawning in selected reaches of the Chiwawa River and Nason Creek in 2005. Vertical bars denote 95% confidence interval.

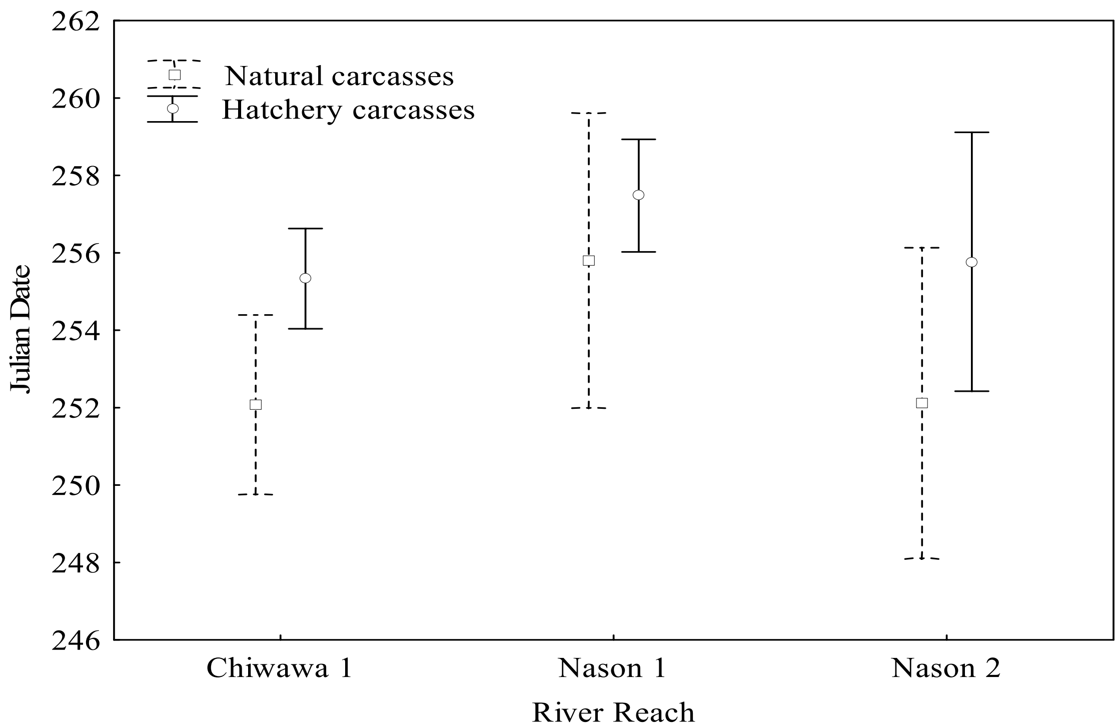

Figure 5. Mean date female spring Chinook carcasses were recovered in selected reaches of the Chiwawa River and Nason Creek in 2005. Vertical bars denote 95% confidence interval.

Survival to Spawning

In 2005, the Wenatchee River Basin experienced severe drought conditions. The proportion of spring Chinook that migrated upstream of Tumwater Dam and subsequently accounted for on the spawning grounds was 42.4%. Differences between run and spawning escapement estimates may be the result of fall back, undetected spawning, or inaccurate redd expansion values. Fallback at Tumwater Dam has not been a significant factor. No PIT tag recaptures were reported at any hydroelectric dam or at LNFH. Furthermore, the number of redds found downstream of Tumwater Dam does not account of the differences observed upstream of Tumwater Dam. Due to record low discharge observed in 2005, it is unlikely that any spawning was undetected. The use of sex ratios as a redd expansion factor does assume each female construct only one redd and males spawn with only one female. Hence, if these assumptions are not valid, the estimated spawning escapement would be an overestimate and the actual difference between run and spawning escapement estimates would be greater.

Poor survival was presumably attributed to extreme environmental conditions prior to and during spawning as a result of record low discharges in the Wenatchee Basin. The estimated number of fish by origin and age was calculated from carcasses recovered during spawning ground surveys and using the estimated age compositions derived from carcass probabilities. The number of hatchery and natural origin spring Chinook in each age class were calculated from carcass recoveries (Table 14). Differences were detected between the proportion of hatchery and natural origin fish at Tumwater and on the spawning grounds ($\chi^2 = 6.01$, df = 1, $P < 0.02$). However, no difference was detected between Tumwater Dam and the estimated spawning population ($\chi^2 = 3.27$, df = 1, $P = 0.07$). Differences observed on the spawning grounds are due to differences in the age composition of hatchery and natural origin spring Chinook (See Chapter 1) and the subsequent size related bias in carcass recoveries. After the bias was corrected using carcass recovery probabilities, no difference was detected in the proportion of hatchery and natural spring Chinook on the spawning grounds. These results are consistent with comparisons between the age composition of hatchery and natural origin spring Chinook (See Spawning Ground Summary) and suggest the survival of hatchery and natural origin spring Chinook from Tumwater Dam to the spawning ground was not different. In the future, a basin specific recovery probability model will be developed.

Table 14. Age and origin of Wenatchee Basin spring Chinook at Tumwater Dam, estimated from carcasses on the spawning grounds, and the estimated number derived using carcass recovery probabilities (H= hatchery; N = natural).

Source	Age-3		Age-4		Age-5		Number of fish		Proportion	
	H	N	H	N	H	N	H	N	H	N
2004										
Tumwater Dam	745	28	331	755	5	8	1,081	789	0.56	0.44
Spawning grounds	382	13	309	887	4	13	695	913	0.43	0.57
Estimated number	674	23	233	669	2	7	909	699	0.57	0.43
2005										
Tumwater Dam	128	9	2,819	381	12	81	2,959	471	0.86	0.14
Spawning grounds	23	2	1,198	203	0	46	1,221	251	0.83	0.17
Estimated number	58	5	1,176	199	0	34	1,234	238	0.84	0.16

Redd Microhabitat Characteristics

Spring Chinook redd microhabitat variables were measured on 68 redds in the Chiwawa River and 69 redds in Nason Creek (Appendix D). Redd microhabitat characteristics may be influenced by habitat availability (spatial distribution) and discharge (temporal distribution). In order to reduce the natural variation in the analysis, only those redd which overlapped in elevations and the difference in discharge (i.e., between the day the redd was constructed and microhabitat measurements were recorded) did not exceed 10% were included in the analysis. All tributaries, except Panther Creek a tributary of the White River, have discharge gauging stations. The change in river discharge for all redds was calculated using the mean daily discharge on the day a redd was constructed and the day when the redd was measured.

Although differences in microhabitat characteristics were detected between streams ($F = 2.25$, $df = 55$, $P < 0.03$), no differences was detected for redds constructed by hatchery and natural origin female spring Chinook in the Chiwawa River or Nason Creek ($F = 0.54$, $df = 55$, $P = 0.87$). Comparisons between years were not conducted because of poor sample size (Table 15). In the Chiwawa River, no significant correlations were found between female fork length and the variables examined. Weak significant correlations were found between female fork length and redd depth ($r = 0.45$, $P < 0.05$), bowl depth ($r = 0.51$, $P < 0.05$), and tail depth ($r = 0.42$, $P < 0.05$) in Nason Creek.

Table 15. Summary of spring Chinook redd microhabitat variables measured in the Wenatchee River Basin in 2005.

Stream	Variable	Hatchery			Natural		
		Mean	SD	*N*	Mean	SD	*N*
		2004					
Chiwawa	Female FL (cm)	76.9	4.0	10	77.8	4.5	25
	Mean water depth (m)	0.38	0.10	10	0.43	0.10	25
	Bowl depth (m)	0.13	0.04	10	0.12	0.05	25
	Tail depth (m)	0.15	0.05	10	0.23	0.10	25
	Bowl front depth (m)	0.46	0.06	10	0.50	0.12	25
	Redd length (m)	5.8	1.3	10	5.8	1.3	25
	Redd width (m)	3.2	0.9	10	4.7	0.9	25
	Redd area (m^2)	18.8	7.9	10	21.5	7.9	25
	Bowl front velocity (m/s)	0.57	0.16	10	0.48	0.16	25
	Tail front velocity (m/s)	0.61	0.17	10	0.56	0.17	25
Nason	Female FL (cm)	71.4	2.7	7	71.9	4.8	31
	Mean water depth (m)	0.39	0.10	7	0.38	0.10	31
	Bowl depth (m)	0.09	0.04	7	0.10	0.03	31
	Tail depth (m)	0.11	0.04	7	0.14	0.07	31
	Bowl front depth (m)	0.41	0.10	7	0.42	0.12	31
	Redd length (m)	7.9	2.2	7	6.0	1.2	31
	Redd width (m)	3.7	1.0	7	3.5	1.0	31
	Redd area (m^2)	28.9	1.5	7	21.4	9.1	31
	Bowl front velocity (m/s)	0.72	0.20	7	0.48	0.17	31
	Tail front velocity (m/s)	0.63	0.11	7	0.50	0.17	31
		2005					
Chiwawa	Female FL (cm)	79.9	4.3	19	79.3	6.1	9
	Mean water depth (m)	0.3	0.1	19	0.3	0.1	9
	Bowl depth (m)	0.1	0.1	19	0.1	0.1	9
	Tail depth (m)	0.2	0.1	19	0.1	0.1	9
	Bowl front depth (m)	0.4	0.1	19	0.4	0.1	9
	Redd length (m)	6.4	2.0	19	7.2	1.9	9
	Redd width (m)	3.8	0.9	19	4.5	1.8	9
	Redd area (m^2)	25.4	10.4	19	33.6	16.6	9
	Bowl front velocity (m/s)	0.31	0.14	19	0.31	0.12	9
	Tail front velocity (m/s)	0.33	0.14	19	0.36	0.14	9
Nason	Female FL (cm)	79.6	4.9	30	83.5	6.4	10
	Mean water depth (m)	0.3	0.1	30	0.3	0.1	10
	Bowl depth (m)	0.1	0.1	30	0.1	0.0	10
	Tail depth (m)	0.2	0.0	30	0.2	0.1	10
	Bowl front depth (m)	0.3	0.1	30	0.4	0.2	10
	Redd length (m)	6.4	1.6	30	5.9	1.2	10
	Redd width (m)	4.2	1.1	30	4.1	0.8	10
	Redd area (m^2)	27.5	11.2	30	24.3	7.7	10
	Bowl front velocity (m/s)	0.38	0.16	30	0.36	0.13	10
	Tail front velocity (m/s)	0.37	0.12	30	0.35	0.13	10

Summary

Spring Chinook survival from Tumwater to the spawning grounds was the lowest observed in the last seven years (WDFW, unpublished data). However, no difference in survival between hatchery and natural origin fish was detected. Poor survival was attributed to the drought condition that existed before and during spawning. The spawning distribution between tributaries of the upper Wenatchee River Basin spring Chinook population was similar to that observed in previous years (Mosey and Murphy 2002). Hatchery female and male spring Chinook spawned in the lower reaches of the Nason Creek and the Chiwawa River, while natural origin female spring Chinook spawned in the upper reaches. Differences in reproductive success of hatchery and natural origin fish may differ because of differences in spawning location.
No difference in spawn timing was found in the natural or hatchery environment. On the spawning grounds, spawn timing comparisons using the date redds were constructed or the date female spring Chinook carcasses were recovered had similar results. The use of carcass recovery data as a surrogate for spawning timing was used successfully in both 2004 and 2005. Should results be consistent across years, greater statistical power may be achieved simply be using all carcasses in the analysis.

No differences were detected in any of the redd microhabitat variables examined. The selection of specific spawning reaches minimized the temporal and spatial variation in the naturally spawning population and will be used in future years. The relatively low abundance of natural origin spring Chinook in 2005 limited the sample sizes used in the analysis. However, these data may be pooled across years and provide greater statistical power in our final report.

Acknowledgements

The Bonneville Power Administration provided funding for this project. We thank Jonathan McCloud, the administrator for this project, for supporting our unique contracting requirements. We would like to thank Chelan County Public Utility District for assistance and funding in conducting spawning ground and carcass surveys. We would also like to thank the numerous members of the WDFW Supplementation Research Team technicians for their assistance in data collection. John Sneva of the WDFW Scale Lab read all the scale samples.

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Chapter 4

Assortative pairing of adult hatchery and natural origin spring Chinook on the spawning grounds and incidence of precocious males in the Wenatchee River Basin

Abstract

PIT tag detections were used to determine composition of adult hatchery and natural origin spring Chinook salmon on individual redds. Snorkel surveys were used to determine the origin and abundance of precocious males on redds. The estimated number of precocious males that potentially contributed to natural spawning was 106 (19 hatchery, 68 natural, and 19 unknown origin). The low relative abundance of precocious males observed on the spawning grounds suggests that the majority of the precocious males observed at Tumwater Dam do not successfully migrate to the major spawning areas or die before spawning. In 2005, the precocity rate was calculated as 0.13% for juveniles released from Chiwawa Ponds, migrated downstream, and survived to pass upstream of Tumwater Dam. Assortative pairing analysis was limited in 2005 because of the lack of externally marked hatchery fish. No difference was detected in the mean fork length of males paired with either hatchery or natural origin females.

Introduction

Salmon are known to select mates based on factors such as competitive dominance and fish size. Selection of mates that are similar to each other (e.g., large size) is termed assortative mating. We are aware of few studies that have investigated assortative pairing of hatchery and natural origin salmon in the natural environment. Assortative pairing by origin (e.g., hatchery or natural) may be a detriment to integrated hatchery populations because the goal is to have hatchery and wild fish interbreed. Hatchery origin fish may pair with other hatchery fish because they are larger, migrate at a certain time, or look different (e.g. adipose fin absent). Some have observed pairs of fish migrating upstream and have speculated that fish pair up prior to reaching the spawning grounds. In this study, we compare the composition and characteristics of hatchery and natural origin fish at Tumwater Dam (potential spawners) with the pairing of fish on redds to determine if assortative pairing occurs.

The number of age 1+ precociously mature salmon on the spawning grounds may be significantly increased by hatchery programs (Reviewed by Mullan et al. 1992) and these fish have the potential to breed with anadromous females. Hatcheries may enhance precocious maturation of males by the kinds of diets that are fed to fish (e.g., high fats) or the types of growth schedules that fish are placed on. For example, approximately, 40% of the males produced by the Yakima Klickitat Fisheries Project (YKFP) spring Chinook supplementation hatchery are precocious males and some of these fish are observed on the spawning grounds approximately four months after they are released from acclimation sites (Larsen et al. 2004). Preliminary results from the YKFP indicate that precocious males sired a significant number of offspring in an experimental spawning channel that contained anadromous males and females (Schroder et al. 2005). Age 1+ precocious males may migrate downstream, but generally do not reach the ocean. These fish are undesirable because of the potential for negative ecological and genetic impacts to natural fish, and because they are an undesirable fishery product. For example, a high incidence of precociously maturing males will lead to direct ecological interactions with native conspecifics and other non-target species of concern. Also, age structure, sex ratio and, potentially, other phenotypic characters of the spawning population will be altered. Precocity and other forms of residualism in hatchery fish is an expression of the genotype x environment interaction. To the extent that the phenomenon has in part a genetic basis and is coupled with changes in the reproductive potential of individuals within the hatchery population as a whole, high precocity or residualism is a source of domestication selection. In this study, we will examine if hatchery precocious males are (1) produced by the hatcheries in question, (2) observed on the spawning grounds, and (3) contribute genetic material to future generations (i.e., progeny attributed to unknown male parentage).

Methods and Materials

Spawning Ground and Snorkel Surveys

During spawning ground surveys active redds were snorkeled to count the number of precociously maturing fish associated with each redd. Active redds were defined as new redds with anadromous fish present. A single snorkeler began approximately 10 m downstream of the active redd and slowly moved upstream. The origin of all spring Chinook observed and the number of precocious fish was recorded. The mean number of precocious fish per redd were calculated for each stream by dividing the number of fish observed while snorkeling by the number of redds snorkeled. The proportion of redds with precocious fish and the mean number and origin of precocious fish per redd was calculated for each stream.

Chinook salmon that are on or associated with active redds were counted and identified to sex and size while snorkeling. Similar information was collected from redds using PIT tag detections (i.e., not snorkeled). Surveys were conducted weekly and lasted throughout the spawning season. Active redds (the presence of an anadromous fish) were found by floating downstream in an inflatable raft or by walking. When a salmon redd was observed and adult salmon were present, then a snorkeler entered the water. A snorkeler began 5-10 meters downstream of the redd and snorkeled upstream, counting all spring Chinook encountered. Fish were categorized as either being on the redd (in the bowl), or associated with the redd (within 5 meters). Hatchery fish were distinguished from natural fish by the presence (natural) or absence (hatchery) of an adipose fin or in the case of adipose fin present hatchery fish through PIT tag detections on the spawning grounds. Anadromous fish were distinguished from precocious males based on size. Anadromous fish are generally greater than 400 mm and precocials are generally less than 300 mm. Females were distinguished from males by the mouth shape and the condition of the caudal fin. Males have a kype and females have a white band on the margin of the caudal fin from digging a redd. After a redd was snorkeled, it was flagged and numbered for subsequent redd measurements.

Data Analysis

The mean number of precocious males per redd was calculated by dividing the number of precocious male observed by the number of redds snorkeled in each stream. Stream specific values (i.e., number of precocious males/redd) were multiplied by the total number of redds in each stream to estimate the total number of precocious males.

As stated previously, the origin of all the males could not be determined. The lack of externally marked hatchery fish in 2005, limited the analysis between origins to only female spring Chinook. However, the fork length of the dominant male was estimated using a linear regression model of estimated and actual fork lengths determined from PIT tag recaptures on the spawning grounds. The mean fork length of males paired with hatchery and natural origin female spring Chinook was compared using a Mann-Whitney U-test. Correlation analysis was conducted on female (hatchery and natural) and male fork length. Differences in the size of males for a female of a given length would suggest assortative pairing was occurring.

Results and Discussion

A total of 84 redds (10.3%) were snorkeled in the upper Wenatchee River Basin during spawning ground surveys (Table 1). Water clarity limited snorkeling on the Chiwawa River, which contained the greatest number of redds in the Wenatchee Basin. Of the 49 redds snorkeled on the Chiwawa River, only 2 hatchery, 6 naturally produced, and 2 unknown origin precocious fish were observed. Water clarity was excellent in Nason Creek and the Little Wenatchee River. Of those redds snorkeled, one redd had one naturally produced precocious fish present. Age 0+ precocious males (i.e., FL < 80 mm) were not observed during any of the surveys. The high discharge in the upper Wenatchee River limited our ability to conduct snorkel surveys in this area. Snorkel surveys were not conducted on the White River due to poor water clarity (i.e, glacial till in the river).

Table 1. Precocious males found during spawning ground surveys on the upper Wenatchee River basin in 2005 (H = hatchery; N = natural; U = unknown).

Stream	Redds snorkeled	Number of precocious males			Mean number of precocious males per redd			
		H	N	U	H	N	U	Total
			2004					
Chiwawa	20	2	7	0	0.10	0.35	0.00	0.45
Nason	73	0	2	0	0.00	0.27	0.00	0.03
White (Panther)	2	0	0	0	0.00	0.00	0.00	0.00
Upper Wenatchee	9	0	0	0	0.00	0.00	0.00	0.00
Total Upper Basin	104	2	9	0	0.02	0.09	0.00	0.11
			2005					
Chiwawa	49	2	6	2	0.04	0.12	0.04	0.20
Nason	22	0	1	0	0.00	0.05	0.00	0.05
Upper Wenatchee	7	0	0	0	0.00	0.00	0.00	0.00
Little Wenatchee	6	0	0	0	0.00	0.00	0.00	0.00
Total Upper Basin	84	2	7	2*	0.02	0.09	0.02	0.13

*Origins not determined due to poor visibility.

An estimated 76 precocious males (13 hatchery, 50 natural, and 13 unknown origin) potentially contributed gametes during spawning in 2005. None of the 297 precocious males sampled at Tumwater Dam were detected or recovered on the spawning grounds. The mark rate of the 2003 brood Chiwawa spring Chinook was 97.4%. The mark rate of the precocious fish sampled at Tumwater Dam was 100.0%. Hence, assuming all precocious fish sampled at Tumwater Dam were from the Chiwawa Ponds and all precocious fish migrated below Tumwater Dam, the precocity rate of the 2003 brood Chiwawa spring Chinook was 0.13% (222,131 fish released in 2005). The probability of recovering age-2 fish carcasses was estimated as zero. The mean (standard deviation, SD) size of the age-2 fish sampled at Tumwater Dam was 210 (16) mm. Zhou (2002) reported that no tagged fish less than 350 mm was recovered over 11 years in the Salmon River, Oregon. Thus, carcass surveys likely underestimate the contribution of precocious males and necessitate the need for snorkel surveys.

Observations of pairings on the spawning grounds were severely limited in 2005 because age-4 hatchery fish were not adipose fin-clipped. The origin and sex of a relatively small number of pairings (i.e., both male and female) on the spawning grounds were determined from PIT detections. Of which, 69% were recorded on the White River (Table 2). Female hatchery spring Chinook were paired with similar proportions of hatchery (52%) and natural (48%) male spring Chinook. Conversely, natural origin spring Chinook were paired predominately (88%) with natural origin male spring Chinook. These results are consistent with the differences in the spawning distribution detected between hatchery and natural origin female spring Chinook (see Chapter 3). Statistical comparisons will be possible as the number of adipose fin-clipped hatchery spring Chinook increases in subsequent years.

No difference was detected in the estimated mean fork length of male spring Chinook paired with hatchery or natural origin female spring Chinook ($Z = -0.74$, $P = 0.46$). Statistical comparisons of the relationship between hatchery and natural origin female fork length and the estimated male fork length could not be performed because requisite assumptions of data normality and equal variances could not be met. However, no significant correlation was found between female and male fork length for either hatchery ($P = 0.67$) or natural ($P = 0.39$) spring Chinook.

Summary

The incidence of precocious males in the Wenatchee River Basin is low and may be due in part to the relatively low prey productivity of the basin. Yearling spring Chinook smolts rarely exceed 100 mm in fork length at time of emigration (WDFW, unpublished data). Precocity in the hatchery population also appears to be very low. Pearsons et al. (2004) reported that 73% of the estimated number of precocious males in the upper Yakima Basin were found in the most downstream reaches of potential spawning habitat. The low abundance of hatchery precocious fish on the spawning grounds in the Wenatchee Basin suggests that most hatchery precocious fish do not successfully migrate to the tributary spawning areas, or they die, as observed in the upper Yakima Basin.

Data collected in 2005 suggests that mate pairing in the Wenatchee Basin is random with respect to the variables that we measured. These data will be used in conjunction with the DNA pedigree analysis (See Chapter 2), which should also provide information about mate selection.

Table 2. Pairing of hatchery and natural origin spring Chinook on redds in the upper Wenatchee River Basin in 2004 and 2005.

Stream	Female origin	Number of females	Number of males		
			Natural	Hatchery	Unknown (Jacks)
2004 Single Pairings					
Chiwawa	H	12	7	2	3
	N	16	14	2	0
Nason	H	6	2	0	4
	N	22	18	0	4
Wenatchee	H	1	0	0	1
	N	1	1	0	0
White	H	0	0	0	0
	N	6	5	1	0
Little	H	0	0	0	0
	N	1	1	0	0
2004 Multiple Male Pairings					
Chiwawa	H	7	8	8	9
	N	19	39	9	12
Nason	H	7	7	3	6
	N	26	50	5	19
Wenatchee	H	0	0	0	0
	N	0	0	0	0
White	H	3	10	0	0
	N	3	7	0	0
Little	H	0	0	0	0
	N	0	0	0	0
2005 Single Pairings					
Chiwawa	H	3	1	2	0
	N	0	0	0	0
Nason	H	5	2	3	0
	N	1	0	1	0
Wenatchee	H	0	0	0	0
	N	0	0	0	0
White	H	13	6	7	0
	N	3	1	2	0
Little	H	1	1	0	0
	N	0	0	0	0
2005 Multiple Male Pairings					
Chiwawa	H	2	2	2	0
	N	0	0	0	0
Nason	H	0	0	0	0
	N	0	0	0	0
Wenatchee	H	0	0	0	0
	N	0	0	0	0
White	H	9	11	11	0
	N	2	0	4	0
Little	H	0	0	0	0
	N	0	0	0	0

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Appendix A. Daily number of spring Chinook observed at Tumwater Dam during trapping in 2005 (F = female; M = male; J = jack; P = precocious male).

Date	Natural			Hatchery				Unknown			Daily Total
	F	M	J	F	M	J	P	F	M	J	
05/14/05		1									1
05/15/05		1									1
05/16/05									1		1
05/17/05				1							1
05/18/05	1			1	1						3
05/19/05		1									1
05/20/05	1			2							3
05/21/05	1	2		2	2						7
05/22/05	1			3	1						5
05/23/05											0
05/24/05	3	2		6	3						14
05/25/05	1	1		6	4						12
05/26/05	3			9	5						17
05/27/05	2	2		9	7						20
05/28/05	1	1		10	6						18
05/29/05	1	4		14	9						28
05/30/05	9	8		42	32		1		1		93
05/31/05	4	6		42	17		1	1			71
06/01/05	5	3		33	19		4				64
06/02/05	3	4		19	18		1	1	1		47
06/03/05	2	3		30	12			2			49
06/04/05	1	2		34	17			1			55
06/05/05	1	2		19	10						32
06/06/05	1			8	10	1					20
06/07/05	1	2		19	13						35
06/08/05	1			24	27	3					55
06/09/05	3	3		26	16	2					50
06/10/05	7	8		56	28	1			1		101
06/11/05	7	6		55	14	1		1	1		85
06/12/05	3			33	17				2		55
06/13/05	4	3	1	53	28	1					90
06/14/05		3		40	22	2	1	1			69
06/15/05	5	4		60	37	2		1			109
06/16/05	10	9		60	44	2	2		1		128
06/17/05	11	2	2	72	36	6	1	1			131
06/18/05	10	5	1	50	22		2				90
06/19/05	14	6		54	36	2	4				116

Date	Natural			Hatchery				Unknown			Daily Total
	F	M	J	F	M	J	P	F	M	J	
06/20/05	7	8		65	36	3	2				121
06/21/05	7	6		72	47	1	2				135
06/22/05	5	12	1	66	49	6	3		1		143
06/23/05	4	7		29	36	8	9	3			96
06/24/05	9	6	1	45	37	4	4				106
06/25/05	8	7		54	34	1	5		1		110
06/26/05	11	5		68	51	5	5	1	2		148
06/27/05	8	5		53	35	6	1	1			109
06/28/05	3	6		28	16	3	3				59
06/29/05	3	5		34	34	5	7				88
06/30/05	9	7		57	37	10	8	1			129
07/01/05	6	14		74	40	7			1		142
07/02/05	6			27	36	4	2				75
07/03/05	5	3		18	14	3	7				50
07/04/05	7	15		37	39	4	2				104
07/05/05	8	6		42	28	3					87
07/06/05	7	12		50	24	7	9	1		1	111
07/07/05	4	7		20	19	3	9		2		64
07/08/05	5	3		24	12	3	8	1			56
07/09/05		3		8	2	3	4				20
07/10/05	2	5	1	11	12	1	7	1			40
07/11/05	4	2		17	10	2	9				44
07/12/05	6	4	2	15	8		6				41
07/13/05	5	6		13	10	3	22				59
07/14/05	2	4		4	8	2	11				31
07/15/05	7	1		6	4	1	14				33
07/16/05		1		2	1	1	7				12
07/17/05	2	2		1	2	2	11				20
07/18/05	5	2		8	5	2	15				37
07/19/05	2	2		4	3	1	10				22
07/20/05	4	7		2	4	3	9				29
07/21/05		2		1	3	3	14				23
07/22/05	3			2	5		11				21
07/23/05		1		2	1		9				13
07/24/05	1	2		2		2	2				9
07/25/05				1			3				4
07/26/05					1						1
07/27/05	2	1			2		9				14
07/28/05				3	1		6				10

Date	Natural			Hatchery				Unknown			Daily Total
	F	M	J	F	M	J	P	F	M	J	
07/29/05				0			6				6
07/30/05				0			3				3
07/31/05				0	3	1	3				7
08/01/05				1							1
08/02/05				1							1
08/03/05											0
08/04/05					1		1				2
08/05/05											0
08/06/05				1			1				2
08/07/05		1									1
08/08/05	1						1				2
08/09/05		1	1	1							3
08/10/05											0
08/11/05											0
08/12/05											0
08/13/05											0
08/14/05											0
08/15/05											0
08/16/05											0
08/17/05	1*										1
08/18/05											0
08/19/05											0
08/20/05											0
08/21/05											0
08/22/05	1*										1
08/23/05											0
08/24/05											0
08/25/05											0
08/26/05											0
08/27/05											0
08/28/05											0
08/29/05	1*										1
08/30/05											0
Total	288	275	10	1861	1223	136	297	18	15	1	4124

* Video recorded counts, sex not determined.

Appendix B. Spring Chinook spawn timing in the upper Wenatchee River Basin in 2005.

Date	Stream					Daily Total	Cumulative Total
	Nason	Chiwawa	Wenatchee	Little Wenatchee	White		
08/01/2005	0	0	0	0	0	0	0
08/02/2005	0	0	0	0	0	0	0
08/04/2005	1	1	0	0	0	2	2
08/07/2005	0	0	0	0	0	0	2
08/08/2005	0	0	0	0	0	0	2
08/10/2005	0	0	0	0	0	0	2
08/11/2005	1	4	0	0	0	5	7
08/14/2005	0	0	0	0	0	0	7
08/15/2005	0	5	0	0	1	6	13
08/17/2005	0	3	0	0	0	3	16
08/18/2005	1	15	0	1	0	17	33
08/21/2005	0	0	0	0	0	0	33
08/22/2005	3	10	0	0	2	15	48
08/24/2005	0	31	0	0	1	32	80
08/25/2005	8	15	0	3	12	38	118
08/28/2005	0	23	0	0	3	26	144
08/29/2005	11	33	0	4	14	62	206
08/31/2005	7	46	1	10	10	74	280
09/01/2005	13	27	0	6	9	55	335
09/04/2005	21	21	0	3	4	49	384
09/05/2005	10	18	0	17	5	50	434
09/07/2005	28	15	34	0	6	83	517
09/08/2005	7	16	0	1	1	25	542
09/11/2005	43	6	1	3	3	56	598
09/12/2005	22	7	14	7	7	57	655
09/14/2005	2	8	0	4	4	18	673
09/15/2005	7	6	5	1	3	22	695
09/18/2005	7	5	0	0	1	13	708
09/19/2005	0	5	88	1	0	94	802
09/21/2005	0	12	0	1	0	13	815
09/22/2005	1	0	0	2	0	3	818
09/25/2005	0	0	0	0	0	0	818
09/26/2005	0	0	0	0	0	0	818
09/28/2005	0	0	0	0	0	0	818
09/29/2005	0	0	0	0	0	0	818
Total	193	332	143	64	86	818	818

Appendix C. Spring Chinook spawning ground reaches in the upper Wenatchee River Basin (CG = campground).

River (*Tributary*)	Reach	River kilometer
Chiwawa River		
Mouth to Grouse Creek	C1	0 – 19.5
Big Meadow Creek		0 – 1.5
Grouse Creek to Rock Creek CG	C2	19.5 – 32.2
Chikamin Creek		0 – 1.0
Rock Creek		0 – 1.0
Rock Creek CG to Schaefer Creek CG	C3	32.2 – 37.3
Schaefer Creek CG to Atkinson Flats	C4	37.3 – 42.7
Atkinson Flats to Maple Creek	C5	42.7 – 45.0
Maple Creek to Trinity	C6	45.0 – 50.5
Little Wenatchee River		
Mouth to Old fish weir	L1	0 – 4.5
Old fish weir to Lost Creek	L2	4.5 – 8.7
Lost Creek to Rainy Creek	L3	8.7 – 15.3
Rainy Creek to Waterfall	L4	15.3 – 21.0
Nason Creek		
Mouth to Kahler Cr. Bridge	N1	0 – 6.5
Kahler Cr. Bridge to Hwy.2 Bridge	N2	6.5 – 13.8
Hwy.2 Bridge to Lower Railroad Bridge	N3	13.8 – 22.0
Lower Railroad Bridge to Whitepine Cr.	N4	22.0 – 25.7
Whitepine Cr. to Upper Railroad Bridge	N5	25.7 – 26.3
Upper Railroad Bridge to Falls	N6	26.3 – 27.0
White River		
Mouth to Sears Cr. Bridge	H1	0 – 10.7
Sears Cr. Bridge to Napeaqua River	H2	10.7 – 18.3
Napeaqua River		
Napeaqua R. to Grasshopper Meadows	H3	18.3 – 21.5
Panther Creek		
Grasshopper Meadows to Falls	H4	21.5 – 23.8
Wenatchee River		
Tumwater Dam to Tumwater Bridge	W8	51.5 – 59.3
Tumwater Bridge to Chiwawa River	W9	59.3 – 80.7
Chiwaukum Creek		
Chiwawa River to Lake Wenatchee	W10	80.7 – 90.3

Appendix D. Spring Chinook redd microhabitat variables measured in the Wenatchee river Basin in 2005.

Variable	Hatchery			Natural		
	N	Mean	SD	*N*	Mean	SD
	Chiwawa River (rkm 27.9 – 32.2)					
Bowl Front Depth	16	0.42	1.37	9	0.48	0.12
Bowl Depth	16	0.16	0.04	9	0.17	0.07
Redd Depth	16	0.38	0.07	9	0.43	0.09
Tail Depth	16	0.21	0.08	8	0.20	0.10
Bowl Front Velocity	16	0.42	0.16	9	0.38	0.17
Tail Front Bottom Velocity	16	0.23	0.10	9	0.24	0.10
Distance to Cover	16	2.93	4.04	9	1.17	1.77
Distance to Nearest Redd	16	20.20	24.20	9	18.8	20.19
Tail Substrate Boulder	16	0.00	0.00	9	0.00	0.00
Tail Substrate Cobble	16	11.00	19.00	9	10.78	15.94
Tail Substrate Gravel	16	70.00	25.00	9	73.33	15.00
Tail Substrate Sand	16	13.00	12.00	9	15.89	14.35
Female Fork Length	16	76.00	8.24	9	79.56	4.30
	Chiwawa River (rkm 23.2 – 27.9)					
Bowl Front Depth	3	0.56	0.19	1	0.43	
Bowl Depth	3	0.21	0.02	1	0.22	
Redd Depth	3	0.47	0.20	1	0.37	
Tail Depth	3	0.28	0.11	1	0.13	
Bowl Front Velocity	3	0.34	0.07	1	0.49	
Tail Front Bottom Velocity	3	0.18	0.01	1	0.38	
Distance to Cover	3	1.00	1.73	1	0.00	
Distance to Nearest Redd	3	17.5	28.17	1	8.00	
Tail Substrate Boulder	3	0.00	0.00	1	0.00	
Tail Substrate Cobble	3	15.00	17.32	1	18.00	
Tail Substrate Gravel	3	80.00	18.03	1	80.00	
Tail Substrate Sand	3	5.00	5.00	1	2.00	
Female Fork Length	3	80.67	3.06	1	88.00	
	Chiwawa River (rkm 19.5 – 23.2)					
Bowl Front Depth	19	0.30	0.12	2	0.29	0.04
Bowl Depth	19	0.11	0.05	2	0.08	0.004
Redd Depth	19	0.28	0.08	2	0.24	0.02
Tail Depth	17	0.14	0.05	2	0.12	0.03
Bowl Front Velocity	19	0.23	0.09	2	0.45	0.11
Tail Front Bottom Velocity	19	0.15	0.05	2	0.35	0.16
Distance to Cover	19	4.76	3.89	2	0.75	5.80
Distance to Nearest Redd	19	7.20	8.27	2	5.70	1.06
Tail Substrate Boulder	19	0.26	1.15	2	0.00	0.00
Tail Substrate Cobble	19	39.21	13.05	2	42.50	10.61
Tail Substrate Gravel	19	43.68	12.68	2	50.00	7.07

Variable	Hatchery			Natural		
	N	Mean	SD	*N*	Mean	SD
Tail Substrate Sand	19	16.84	13.15	2	7.50	3.54
Female Fork Length	19	78.68	3.48	2	80.00	7.07
Chiwawa River (rkm 32.2 – 37.3)						
Bowl Front Depth	3	0.33	0.10			
Bowl Depth	3	0.12	0.01			
Redd Depth	3	0.28	0.11			
Tail Depth	2	0.19	0.01			
Bowl Front Velocity	3	0.22	0.10			
Tail Front Bottom Velocity	3	0.17	0.08			
Distance to Cover	3	4.77	2.97			
Distance to Nearest Redd	3	10.3	8.14			
Tail Substrate Boulder	3	0.33	0.58			
Tail Substrate Cobble	3	21.67	16.07			
Tail Substrate Gravel	3	81.67	7.64			
Tail Substrate Sand	3	8.33	2.89			
Female Fork Length	3	80.00	1.00			
Chiwawa River (rkm 37.3 – 42.7)						
Bowl Front Depth	10	0.40	0.10	5	0.35	0.10
Bowl Depth	10	0.14	0.08	5	0.18	0.07
Redd Depth	10	0.33	0.07	5	0.30	0.03
Tail Depth	10	0.15	0.05	4	0.10	0.05
Bowl Front Velocity	10	0.31	0.10	5	0.32	0.19
Tail Front Bottom Velocity	10	0.18	0.07	5	0.23	0.15
Distance to Cover	10	3.64	4.48	5	3.54	3.96
Distance to Nearest Redd	10	22.42	31.52	5	6.20	10.83
Tail Substrate Boulder	10	0.00	0.00	5	0.00	0.00
Tail Substrate Cobble	10	10.00	5.77	5	10.00	3.54
Tail Substrate Gravel	10	79.00	10.49	5	85.00	3.54
Tail Substrate Sand	10	11.00	10.75	5	5.00	3.54
Female Fork Length	10	79.60	3.17	5	82.40	4.34
Nason River (rkm 0 – 6.5)						
Bowl Front Depth	43	0.32	0.08	5	0.28	0.10
Bowl Depth	43	0.09	0.04	5	0.08	0.04
Redd Depth	43	0.30	0.05	5	0.28	0.07
Tail Depth	43	0.17	0.05	5	0.15	0.06
Bowl Front Velocity	43	0.39	0.18	5	0.37	0.17
Tail Front Bottom Velocity	43	0.22	0.12	5	0.21	0.10
Distance to Cover	43	5.79	5.93	5	4.04	4.49
Distance to Nearest Redd	43	33.12	45.93	5	51.16	83.75
Tail Substrate Boulder	43	3.60	5.70	5	4.00	5.48
Tail Substrate Cobble	43	38.02	12.28	5	36.00	15.17
Tail Substrate Gravel	43	38.02	8.46	5	48.00	13.04

Variable	Hatchery			Natural		
	N	Mean	SD	*N*	Mean	SD
Tail Substrate Sand	43	19.88	10.61	5	12.00	4.47
Female Fork Length	43	79.30	5.63	5	73.60	6.19
	Nason River (rkm 18.8 – 22.0)					
Bowl Front Depth	13	0.30	0.08	8	0.40	0.19
Bowl Depth	13	0.12	0.03	8	0.12	0.03
Redd Depth	13	0.28	0.06	8	0.34	0.13
Tail Depth	13	0.16	0.04	8	0.17	0.09
Bowl Front Velocity	13	0.34	0.14	8	0.31	0.10
Tail Front Bottom Velocity	13	0.21	0.13	8	0.17	0.08
Distance to Cover	13	10.27	8.53	8	5.29	4.51
Distance to Nearest Redd	13	83.46	107.94	8	67.65	59.97
Tail Substrate Boulder	13	2.31	4.39	8	1.25	3.54
Tail Substrate Cobble	13	56.15	15.02	8	50.00	15.12
Tail Substrate Gravel	13	33.08	15.48	8	38.75	17.27
Tail Substrate Sand	13	8.46	5.55	8	10.00	14.14
Female Fork Length	13	82.46	6.50	8	84.38	3.54

Appendix E

A microassay for gill sodium, potassium-activated ATPase in juvenile Pacific salmonids by R.M. Schrock, J.W. Beeman, D. W. Rondorf, and P.V. Haner

Transactions of the American Fisheries Society 123:223–229, 1994

A Microassay for Gill Sodium, Potassium-Activated ATPase in Juvenile Pacific Salmonids

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Abstract.—A microassay well-plate method is described for determining Na^+,K^+-ATPase activities of small gill sections from juvenile Pacific salmon *Oncorhynchus* spp. The method differs from the established macromethod by detecting inorganic phosphate in nanomole rather than micromole concentrations. This permits the use of much smaller tissue samples, which makes it possible to release fish after sampling. Use of sonication during enzyme extraction and elimination of the need to deproteinize samples before ATPase analysis further simplify the assay. Application of the microwell-plate technique for both Na^+,K^+-ATPase activity and protein analysis permits rapid processing of many samples. It also produces results equivalent to those of the macroassay; no significant differences occurred between sample duplicates run by the two methods with the same enzyme extract ($P > 0.05$). The coefficient of variation (100·SD/mean) for microassay samples containing enzyme activities of at least 10 μmol inorganic phosphate per milligram protein per hour was 12% or less for between-plate comparisons and 5% or less for same-plate comparisons. Monitoring of gill-clipped fish during migration indicated that small gill clips did not cause mortality or alter migration behavior of juvenile salmonids tagged with passive integrated transponders. These are important considerations in programs for monitoring species listed under the U.S. Endangered Species Act.

Gill sodium, potassium-activated adenosine triphosphatase levels (Na^+,K^+-ATPase) have been used as a quantitative measurement of the progress of smoltification in migrating salmon (Folmar and Dickhoff 1981; Zaugg 1982a; Dickhoff et al. 1985). Changes in levels of this enzyme have been reported in association with many morphological, physiological, and environmental variables of smoltification (Wedemeyer et al. 1980; Folmar and Dickhoff 1981; Zaugg 1982a; Dickhoff et al. 1985; Sower and Fawcett 1991). The enzyme hydrolyzes ATP to provide energy for ionic transport across gill membranes. The enzyme takes part in the absorption of NaCl across the gill epithelium of freshwater teleosts and excretion of NaCl in marine species (Hoar and Randall 1984; Borgatti et al. 1992).

Absolute concentrations of gill Na^+,K^+-ATPase vary among salmonid species, but there is a single characteristic enzyme profile during the seaward migration. Enzyme activity is low in presmolting fish held in the hatchery, but increases rapidly after fish are released to the river to migrate. Activity continues to rise during migration, then levels off late in the migration (Beeman et al. 1991). Fish held in hatcheries for delayed release may experience a decrease in Na^+,K^+-ATPase activity, then a subsequent rapid increase in activity upon release and during the migration (Zaugg 1982a).

Weekly reporting of gill Na^+,K^+-ATPase activity in migrating salmon is now routine in smolt-monitoring programs in the Columbia River basin (Beeman et al. 1991). The increasing number of samples to be analyzed and the need for quicker turn-over time necessitated the development of a simpler, quicker method than had been used before now. Furthermore, the listing of Pacific salmon stocks as endangered (Snake River sockeye salmon *Oncorhynchus nerka*, December 1991) and threatened (Snake River spring–summer chinook salmon and fall chinook salmon *O. tshawytscha*, April 1992) under the U.S. Endangered Species Act (USOFR 1992) compelled us to reconsider sampling that entailed sacrificing large numbers of fish, as was necessary for the macroassay method. Therefore, the objective of this study was to develop an assay for gill Na^+,K^+-ATPase activity that would be nonlethal, would increase the number of samples that could be assayed in a day, and would yield results equivalent to those of the established procedure. The new method allows detection of inorganic phosphate (a product of ATPase activity) in nanomole rather than in micromole concentrations.

Methods

Sample collection.—Spring chinook salmon and steelhead *O. mykiss* were collected at hatcheries shortly before release and from juvenile fish passage collection systems at dams during the seaward migration (Matthews et al. 1986). Fish were anesthetized with 50–100-mg/L solutions of MS-222 (tricaine methanesulfonate) until they turned on their sides and did not struggle when handled. A small piece of gill filament about 2 × 3 mm (10 mg wet weight) was clipped from the center third of the first gill arch on the left side of the fish and preserved in 0.5-mL buffer solution. The buffer was composed of 0.3 M sucrose, 0.02 M disodium EDTA, and 0.1 M imidazole at pH 7.1 (SEI; unless stated otherwise, all reagent chemicals were from Sigma Chemical Co. and all solutions were made in deionized H_2O). Samples were shaken and placed in an ice bath for 5–15 min, frozen in liquid nitrogen, and stored at −80°C. Gill-clipped fish were immediately placed in aerated water until they revived (15–120 min), then they were returned to the hatchery pond, river, or juvenile transport system. Gill samples for analysis by the standard "macroassay" were collected according to Zaugg (1982b) and were divided before sample preparation to provide duplicate tissue pieces for comparisons of the macroassay with the new microassay.

Sample preparation.—The extraction method of Zaugg (1982b) was adapted for the microassay with the following changes. Samples were partially thawed and ground in a number 20 conical ground glass tissue grinder (Kontes) for 10 strokes. The homogenates were centrifuged for 8 min at 2,000 × gravity, relative centrifugal force (RCF), at room temperature (20°C). The samples were drained and the pellets were resuspended in 100–600 μL of sucrose–disodium EDTA–imidazole–deoxycholate (SEID, at room temperature), a solution of SEI at pH 7.1 with the addition of 2.4 mM deoxycholic acid sodium salt. Sample dilution brought protein concentrations to between 1 and 6 μg/4 μL of sample volume for analysis by the microassay adaptation of the Lowry method (Lowry et al. 1951). The inorganic phosphate concentration range of diluted samples was appropriate for a 2-μL sample volume for the enzyme assay. Samples were kept in an ice bath during all steps of the preparation except during the SEID extraction and centrifugation steps.

The suspended pellets were sonicated with a Sonics and Materials Vibracell model VC60 High Tech Ultrasonic Processor at output 50 for 1–3 s (pulsed 1.0 s on and 0.5 s off) with a 2-mm probe. Samples were centrifuged a second time for 6 min at 2,000 × gravity RCF at room temperature. Immediately after centrifugation, 100 μL of the enzyme preparation supernatant was withdrawn and transferred to a culture tube kept in an ice bath.

Na^+,K^+-ATPase analysis.—Sodium, potassium ATPase activity was determined by measuring the inorganic phosphate (P_i) concentration released during a 10-min incubation with the Na^+,K^+-ATPase reaction mixtures developed by Zaugg (1982b); P_i was determined by the method of Chan et al. (1986) as modified for microassays by Henkel et al. (1988). Protein concentrations were determined with a microassay adaptation of the Miller (1959) modification of the Lowry et al. (1951) protein determination. The ATPase activity was calculated as the difference between the ouabain-insensitive plus ouabain-sensitive Na^+,K^+-ATPase activity (A reaction) and the ouabain-sensitive activity (B reaction), and reported as $\mu mol\ P_i \cdot (mg\ protein)^{-1} \cdot h^{-1}$.

Individual samples from the same aliquot of extracted enzyme preparation were delivered to well plates for the enzyme and protein assays with a multiple-dispensing, automated pipetter. Incubation plates for enzyme activity were processed through the inorganic phosphate analysis immediately after completion of sample pipetting, whereas the protein plates were held at room temperature until a second set of samples was pipetted to the plate.

The following reaction mixture (Zaugg 1982b) was prepared as solution A: 155 mM sodium chloride, 75 mM potassium chloride, 23 mM magnesium chloride, and 115 mM imidazole, adjusted to pH 7.0. Solution B was prepared by adding 0.6 mM ouabain to solution A. Solutions were refrigerated for up to 3 months. Adenosine 5′-triphosphate disodium salt (30 mM Na_2ATP, pH 7.0) was prepared and frozen in 7.0-mL aliquots that were thawed in a room temperature bath just before use.

Malachite green reagent for the P_i determination was prepared daily from the following weight-per-volume (g/100 mL) stock solutions at a 1:1:2:2 ratio: 5.72% ammonium molybdate, 2.32% polyvinyl alcohol, 0.0812% malachite green, and deionized water. The reagent was allowed to mature for 1 h in the light and then was kept in the dark until use. The malachite green reagent mixture was very responsive to light conditions, and although this did not affect final phosphate concentration values, users should control lighting to keep background absorbances low. All stock solutions were stored in dark bottles. Malachite green and ammonium molybdate were stored at room temperature in the dark for up to 3 months. Polyvinyl alcohol was refrigerated and kept 1 month.

Inorganic phosphate standards—0.05, 1.0, and 3.0 nmol/μL—were prepared weekly in SEID from a stock standard (25 × 10^{-3} M K_2HPO_4 in deionized water). The phosphate stock standard kept well at room temperature for up to 9 months. Two-microliter volumes of standards, samples, and controls were used in the microassay.

Enzyme incubation and inorganic phosphate analysis.—A 96-well flat-bottomed microwell plate (Corning) was cooled on a flat ice pack and loaded with 65 μL of solution A in all wells of columns 1–7 and 65 μL of solution B in all wells of columns 8–12 by means of standard eight-channel pipetters. The first column held only reagents due to a consistent, unaccountable variability in first column readings. The second column held duplicates of each of the following: 2 μL of SEID for background readings and inorganic phosphate standards at 1.0, 2.0, and 6.0 nmol/2 μL. Columns 3–7 contained samples and controls treated with solution A for determination of ouabain-insensitive plus ouabain-sensitive Na^+,K^+-ATPase activity. Columns 8–12 contained samples and controls, in the same order as columns 3–7, treated with solution B to assess ouabain-sensitive Na^+,K^+-ATPase activity.

The microwell plate was shaken for 3.5 min at room temperature, and the enzyme reaction was started by pipetting 10 μL of 30 mM Na_2ATP to all wells. Pipetting proceeded, column by column, at a rate corresponding to the speed at which the plate reader would read the plate, thus ensuring equal incubation time for the A and B wells for an individual sample. The plate was shaken for 1 min, then incubated at 37 ± 0.5°C in a water bath for exactly 10 min.

The plate was moved from the water bath to the ice pack and 225 μL of malachite green reagent were pipetted to all wells, again at a column-to-column rate corresponding to the rate of the plate reader. The plate was shaken for 4 min, rested for 6 min, and then read at 630 nm on a Titertek Multiskan Plus MKII type 314 microwell plate reader (ICN Biomedicals, Inc.) exactly 10 min after the addition of malachite green reagent to the first column.

The background absorbance of each plate was set to zero based on the mean of the two wells in column 2 that contained just SEID, and the slope of the standard curve for P_i was calculated from the means of the standard duplicates.

It was necessary to run standards on all plates to accommodate slight variations in temperature and time regimes. A commercial phosphorous standard was analyzed with each plate as a control to provide quality assurance of standard curve readings for individual plate accuracy.

Protein assay.—Three protein stock solutions were prepared: (1) alkaline carbonate, a solution of 0.94 M sodium carbonate plus 0.5 M sodium hydroxide; (2) 0.04 M copper sulphate; and (3) 0.07 M sodium–potassium tartrate. Solutions were stored in dark glass bottles, in the dark, at room temperature for up to 3 months. Alkaline carbonate was checked daily for turbidity and replaced as needed. A 20:1:1 reagent mixture of these solutions was prepared daily.

Bovine serum albumin was used to prepare a 12.0-mg/mL protein stock standard in deionized water that held for 1 month when refrigerated. Protein standards of 0.25, 0.50, and 1.50 μg/μL were prepared weekly from the stock diluted with SEID and were kept at room temperature. A protein control prepared from a commercial human serum control was diluted and run on each plate.

Plate set-up duplicated that for the inorganic phosphate assay, but samples were pipetted into dry wells. Column 1 held reagents only. Duplicates of SEID at 4 μL and of protein standards at 1, 2, and 6 μg/4 μL filled column 2 from top to bottom. Columns 3–7 contained protein samples from a first set of samples with a control, and columns 8–12 contained the protein samples from a second set of samples and a control.

Protein analysis was begun by pipetting 70 μL of the protein reagent mixture to all wells; the plate was then shaken for a 5-min incubation at room temperature. To all wells, 210 μL of Folin's reagent (Folin Ciocalteu's Phenol Reagent, 2.0 N, diluted 1:10 with deionized water) was quickly added. The plate was shaken for 1 min, then incubated for 5 min at 37 ± 0.5°C. The plate was held for 30 min at room temperature in the dark, then read at 700 nm. The background absorbance of each plate was set to zero based on the mean of the two wells in column 2 that contained just SEID, and the standard curve for protein was constructed from the means of the standard duplicates.

Precision, variation, and reproducibility.—Precision of the microassay was calculated with the mean standard deviation of duplicates in the concentration range 0–40 μmol $P_i \cdot (\text{mg protein})^{-1} \cdot h^{-1}$. Precision of duplication was characterized at different concentrations by calculating the standard deviations of 10 duplicate pairs in the concentra-

TABLE 1.—Precision of duplicate measurements in various Na^+,K^+-ATPase activity ranges (N = 10 duplicate pairs for each range).

Activity (μmol Pi·[mg protein]$^{-1}$·h^{-1})			
Range	Mean of duplicates	SD	Coefficient of variation (SD/mean, %)
0–10	6.8	1.2	18
10–20	15.4	1.8	12
20–30	25.1	2.3	9
30–40	34.2	3.6	10

tion ranges 0–10, 10–20, 20–30, and 30–40 μmol P_i·(mg protein)$^{-1}$·h^{-1}. The coefficient of variation (CV) for samples at the mean concentration in each range was calculated with the standard deviation of the duplicates (CV = 100·SD/mean). Ten replicates of two different homogenates were run on the same plate to assess the reproducibility during a single run.

Validation of the microassay.—The microassay was validated by four comparisons: (1) duplicates of the same sample homogenate were analyzed by macroassay (Zaugg 1982b) in separate analytical runs, (2) microassay sample homogenates were duplicated on separate plates, (3) sample homogenates prepared for and run by the macroassay were diluted and run by microassay, and (4) separate enzyme preparations from gill tissue from unknown locations on the gills of the same fish were run by both the macroassay and the microassay. Samples for validation experiments were chosen randomly from routine monitoring analyses and covered the normal range of concentrations from 0 to 52 μmol P_i·(mg protein)$^{-1}$·h^{-1}.

Field test of nonlethal sampling.—The effects of clipping a small amount of gill from migrating juvenile salmon were studied in 1991 in conjunction with ongoing migration and survival studies of fish that had been intraperitoneally implanted with passive integrated transponder tags (PIT tags; Prentice et al. 1990a, 1990b). Spring chinook salmon, hatchery steelhead (adipose fins of hatchery steelhead in the Columbia River basin were removed to distinguish them from wild steelhead), and wild steelhead were collected and PIT-tagged at both the Clearwater and Snake River juvenile salmon traps near Lewiston, Idaho, by staff of the Idaho Department of Fish and Game. The objective of their study was to determine migration rate and detection rate of salmonids at downstream PIT-tag detection stations.

Several hundred fish were PIT-tagged each day at each trap and we were allowed to clip gill tissue from some of them. Based on previous PIT tag releases and detection rates, we tagged, gill-clipped, and released 80 spring chinook salmon, 50 hatchery steelhead and 50 wild steelhead so that about 30 fish from each group would be detected at Lower Granite Dam (52 and 62 km downstream of the Snake and Clearwater traps, respectively). Group PIT tag detections were analyzed with arcsine-transformed data and a parametric one-way General Linear Models procedure. Migration times from traps to Lower Granite Dam were compared by using the nonparametric median test with the chi-squared approximation (SAS Institute 1989).

Results

Precision, Variation, and Reproducibility

Precision of microassay duplicates in the concentration range 0–40 μmol P_i·(mg/protein)$^{-1}$·h^{-1} was 2.8 μmol P_i·(mg protein)$^{-1}$·h^{-1}. However, precision differed at varying levels of ATPase activity (Table 1). The precision of the microassay (95% confidence interval) for a sample of 5.0 μmol P_i·(mg protein)$^{-1}$·h^{-1}, based on the standard deviation of the range (SD = 1.2; Table 1), was 3.4 μmol P_i·(mg protein)$^{-1}$·h^{-1}. The coefficient of variation (CV) was 18% for samples in the range of 0–10-μmol P_i·(mg protein)$^{-1}$·h^{-1} and decreased in higher concentration ranges, leveling off at about 10% in samples with activity exceeding 20 μmol P_i·(mg protein)$^{-1}$·h^{-1} (Table 1).

Ten duplicates of two different homogenates were run on the same plate to assess reproducibility during a single run. The first sample, with a mean of 11.1 μ mol P_i·(mg protein)$^{-1}$·h^{-1}, had a CV of 5% (N = 10, SD = 0.56); the second, with a mean of 25.3 μ mol P_i·(mg protein)$^{-1}$·h^{-1}, had a CV of 4% (N = 10, SD = 1.13).

Validation of the Microassay

Three of four comparisons of macro- and microassays resulted in correlation coefficients (r) of 0.95 or greater (Figures 1–3). The lone exception was the comparison of microassay with macroassay of different tissue preparations (Figure 4; r = 0.89). A significant difference was found between duplicates analyzed by the macroassay (Table 2; $P < 0.002$, t-test for paired comparisons).

Field Test of Nonlethal Sampling

Neither detection rate nor median travel time of PIT-tagged fish at Lower Granite Dam differed significantly between gill-clipped and nonclipped

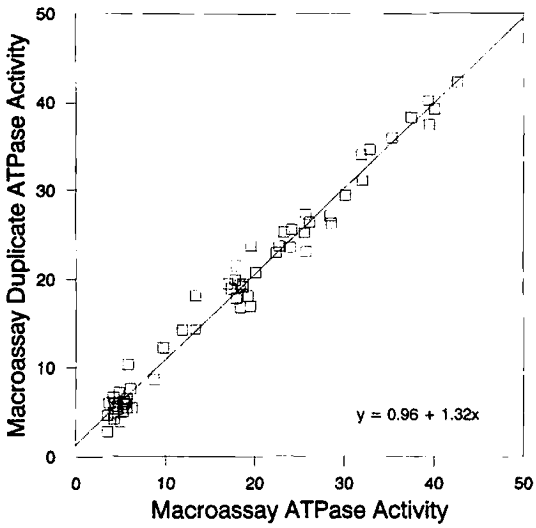

FIGURE 1.—Correlation of gill Na⁺,K⁺-ATPase activity (μmol $P_i \cdot$[mg protein]$^{-1} \cdot h^{-1}$) between duplicate macroassays of the same enzyme extract (N = 60, r = 0.99; y is the ordinate value).

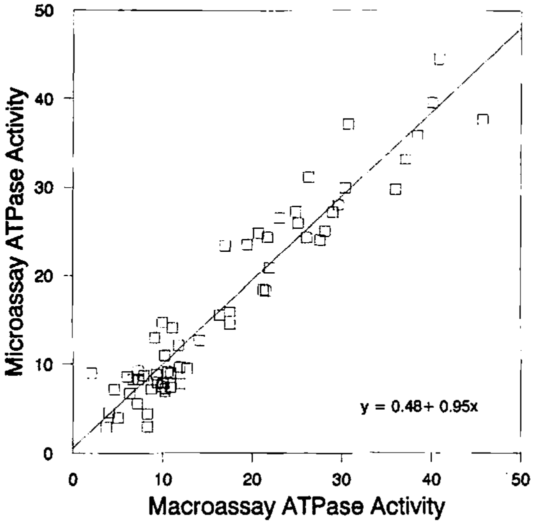

FIGURE 3.—Correlation of gill Na^+,K^+-ATPase activity (μmol $P_i \cdot$[mg protein]$^{-1} \cdot h^{-1}$) between duplicate assays of the same enzyme extract by the macroassay (x) and the microassay (y; N = 60, r = 0.95).

fish for any of the paired groups (Table 3; $P > 0.05$).

Discussion

The nonlethal sampling of gill tissue made possible by the microassay for Na^+,K^+-ATPase activity will allow sampling of fish stocks that may be declining. McCormick (1993) presented a similar microassay for determining Na^+,K^+-ATPase activity with different reagents and verified that removing several gill filaments did not affect growth, condition, or osmoregulation of Atlantic salmon *Salmo salar*. The Na^+,K^+-ATPase microassay presented here is directly comparable

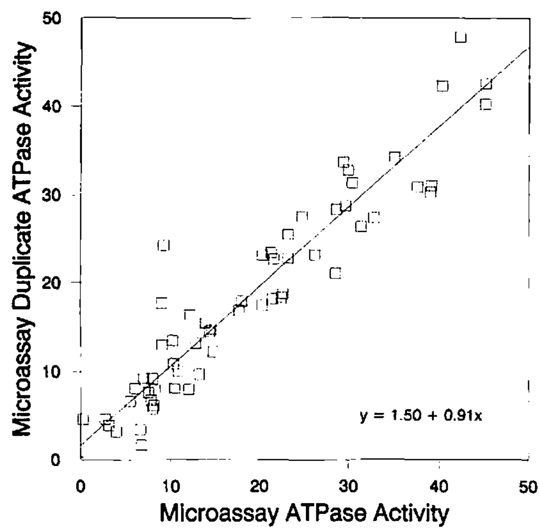

FIGURE 2.—Correlation of gill Na^+,K^+-ATPase activity (μmol $P_i \cdot$[mg protein]$^{-1} \cdot h^{-1}$) between duplicate microassays of the same enzyme extract (N = 60, r = 0.95; y is the ordinate value).

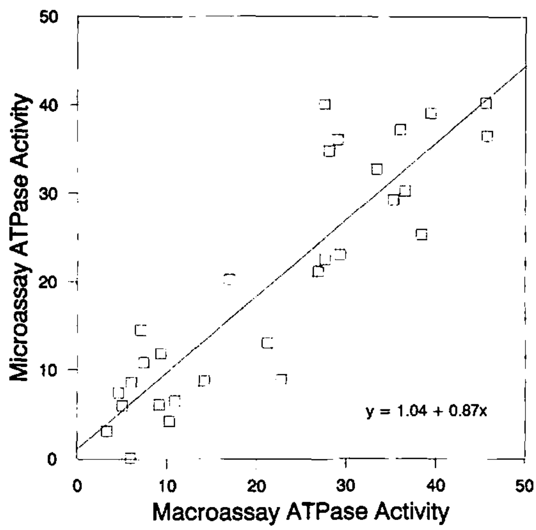

FIGURE 4.—Correlation of gill Na^+,K^+-ATPase activity (μmol $P_i \cdot$[mg protein]$^{-1} \cdot h^{-1}$) by the macroassay (x) and the microassay (y). Separate tissue homogenates of gill tissue from a single fish were assayed by both methods (N = 29, r = 0.89).

TABLE 2.—Student's t-tests for paired comparisons of duplicate Na^+,K^+-ATPase activities (N is number of comparisons).

Duplicate comparison	N	D[a]	t	P
Macroassay duplicates, same tissue extract	60	−0.68 (0.21)	3.29	<0.002
Microassay duplicates, same tissue extract	60	0.30 (0.52)	0.57	>0.05
Macroassay–microassay duplicates, same tissue extract	60	0.34 (0.42)	0.83	>0.05
Macroassay–microassay, separate tissue extracts	29	1.83 (1.18)	1.58	<0.02

[a] D is the mean of the mean activity difference between duplicates; SE is in parentheses. Activity units are μmol Pi·(mg protein)$^{-1}$·h^{-1}.

to the method of Zaugg (1982b), which has been used extensively with Pacific salmon for many years. The microassay is rapid, economical, and as reliable as the method it replaces. The inorganic phosphate analysis that detects P_i in nanomole concentrations easily replaces the more complex protein extraction method of Zaugg and Knox (1966, 1967), modified by Zaugg (1982b). Although sample preparation and enzyme extraction remain the same with minor modifications, the inorganic phosphate and protein assays combined require less than a 10-μL sample.

The methods adapted for use in the microassay have been verified previously by their respective developers (Zaugg 1982b; Chan et al. 1986; Henkel et al. 1988), but observation of a strict protocol is necessary for reliable results. Several factors are of key importance in applying the microassay successfully. Sample loss must be minimized during the extraction process. Samples should be kept in an ice bath except during extraction and centrifugation. The enzyme extract should be mixed immediately before it is pipetted, and the protein aliquot should be pipetted at the same time, from the same aliquot as the ATPase assay subsample. We recommend running the A (ouabain-insensitive plus ouabain-sensitive) and B (ouabain-sensitive) reactions for individual samples on the same microwell plate to permit exact timing of A and B incubation periods. Strict adherence to timing and temperature protocols is necessary for consistent, accurate results.

Our validation of the microassay by comparison with the macroassay provides quality control measurements for laboratories considering conversion to the microassay, as well as assurance that results are equivalent to results from previous years. Microassay duplicates were not significantly different from macroassay duplicates. This, coupled with the agreement of the duplicate enzyme preparation analysis by the two methods, indicates that the microassay and the macroassay provide quantitatively identical values.

TABLE 3.—Travel time and percent PIT tag detection for fish from which micro gill clips had been removed for ATPase analysis and for nonclipped control fish, spring 1991. There were no significant differences in percentage of tags detected or in median travel time in any paired release group ($P > 0.05$).

Species and date released	Number of PIT-tagged fish released: Clipped	Number of PIT-tagged fish released: Nonclipped	Percent of tags detected	Median travel time (d)
Clearwater trap release site				
Spring chinook salmon				
April 11–12	79		36.7	19.7
		301	36.3	22.5
April 26	81		34.6	13.4
		151	42.4	13.3
Steelhead (hatchery)				
April 26	60		76.7	7.2
		57	78.9	7.3
Steelhead (wild)				
April 26	55		56.4	5.4
		50	58.0	5.2
Snake River trap release site				
Spring chinook salmon				
April 11–12	80		46.2	14.6
		85	37.6	12.0
Steelhead (hatchery)				
May 1–2	50		72.0	6.2
		108	74.1	7.1
Steelhead (wild)				
May 13–14	50		56.0	3.2
		207	69.1	3.1

Significant differences in Na^+,K^+-ATPase between gill arches in individual fish have been documented in crude homogenates that were not centrifuged (Johnson et al. 1991). The mean difference between our duplicates was greatest for comparisons between enzyme preparations from two tissue pieces of unknown gill location that were analyzed by the two assay methods. To eliminate the increased variability found among samples from different gill arches in the same fish, we standardized the location of the gill clip to the middle of the first gill arch on the left side of the fish. Activities of tissue duplicates analyzed by the two methods did not differ significantly, but our method requires centrifugation of homogenates during enzyme extraction.

Comparison of detection rates and migration rates of PIT-tagged and untagged control fish indicate that migration performance and survival of gill-clipped fish is similar to that of control fish. The opportunity to release fish to continue their migration is important, because listing of salmon stocks as threatened or endangered increases the accountability of biologists for the numbers of fish they sacrifice.

Acknowledgments

We thank individuals of the Idaho Department of Fish and Game, U.S. Fish and Wildlife Service, state and federal staff of Columbia River basin hatcheries and dams, the Fish Passage Center, the U. S. Army Corps of Engineers, and the Bonneville Power Administration for their help with this study. We also thank our colleagues at the Columbia River Field Station for their assistance. Funding for this research was provided by Bonneville Power Administration under contract DE-A179-87BP35245. Reference to trade names does not imply endorsement by the U.S. Government.

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Received July 6, 1993
Accepted October 15, 1993