Candidate Performance Indicator Suitability Thresholds

Identifying Suitable Thresholds

For each indicator, suitability thresholds or benchmarks must be identified to contextualize the state of the indicator relative to objectives. The Plan defers to established suitability thresholds where they exist, particularly in the case of quantitative suitability thresholds for fish populations that have been developed and proposed or formally adopted by federal, state or tribal agencies. Where such population thresholds do not already exist in a formally adopted document, this planning process will seek to ultimately develop interim qualitative suitability thresholds that are sufficiently specific to be testable (e.g., fall-run Chinook are able to migrate upstream as far as Upper Klamath Lake; fall-run Chinook are able to successfully spawn and rear in tributaries to Upper Klamath Lake). In this regard, traditional knowledge can provide valuable information on historical conditions against which qualitative benchmarks can be calibrated. Since qualitative criteria can often stimulate efforts to develop quantitative criteria, the Plan's criteria should be revisited and updated over time based on progress made in other formal processes.

Identifying Candidate Suitability Thresholds from the Literature

The finalized list of Core Performance Indicators and how they link to the Watershed Tiers and Objectives is provided in the Klamath IFRMP (see Section 2, Table 2-2). Additional thresholds for potential Supplementary Indicators were identified and are provided in herein.

While many of the suitability thresholds identified in the literature apply equally to all species and parts of the basin, some vary widely by species and in some cases cannot be met simultaneously for all species at once. As a result, it will be very important to consider the spatial dimensions of suitability thresholds when interpreting future monitoring data to identify those regions where one suitability threshold might take precedence over another. For example, in an area defined as historical and critical habitat for Pacific lamprey but not other species, suitability thresholds for lamprey make take precedence. This and similar issues will be considered further during the design of a full monitoring and evaluation plan in later phases of this planning process.

Table C - 1. Proposed core performance indicators (CPIs) and published suitability thresholds for POPULATION related objectives. More detailed tables can be provided in appendices.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			Reference
			Poor	Fair	Good	
1.1 Increase juvenile production	Juveniles per adult	count	N/A	N/A	≥ 1.2 naturally-produced adult offspring per adult in three of the last five years when total abundance was less than average returns of naturally produced fish.	Interim criteria and standards for Oregon salmon and steelhead, ODFW 2005[1] referenced in NMFS 2014[2].
1.2 Increase juvenile survival and recruitment to spawning populations	Loss of Tagged Fish by Reach Over Time *(to pinpoint spatial survival constraints)*	NA	NA	NA	NA	Could not find benchmarks for any species – likely captured instead by population productivity / growth rate.
1.3 Increase overall population abundance and productivity, particularly in areas of high existing abundance or potential future abundance or in special or unique populations	Overall Abundance	N/A	Coho: Below "low risk threshold" of spawners for each core population Bull Trout: N/A	Coho: Meets "low risk threshold" of spawners for each core population Bull Trout: < 8,250 in Upper Klamath Basin *(based on 10 yrs of data)*	Coho Exceeds "low risk threshold" of spawners for each core population Bull Trout: ≥ 8,250 in Upper Klamath Basin *(based on 10 yrs of data)* Redband Trout: > 1,250 (per population)	Coho: Table 4-1 and Table 4-2 in NMFS 2014 Bull Trout: Recovery Criteria, p. vi in USFWS 2002[3] Redband Trout: p.20 in IRCT 2016[4]
	Density	varies	Coho: < 4 spawners per IP-km for each non-core population. Redband Trout: ≤ 0.059 fish/m^2 or ≤ 0.2 g/m^2	Coho: N/A Redband Trout: 0.060 – 0.19 fish/m^2 or 2.1 – 4.9 g/m^2	Coho: ≥ 4 spawners per IP-km for each non-core population. Redband Trout: ≥ 0.20 fish/m^2 or ≥ 5.0 g/m^2	Coho: Coho: Table 4-1 in NMFS 2014 Redband Trout: Table 1 in Dambacher and Jones 2007[5]
	Productivity *(Slope of regression of geometric mean of wild adults over multiple generations)*	unitless	<0	0-1	≥1	Coho: Table 4-1 in NMFS 2014 Bull Trout: Recovery Criteria, p. vi in USFWS 2002, *(10 yrs of data)* Eulachon: Criteria on p. 89 of NMFS 2016[6]

[1] Oregon Department of Fish and Wildlife (ODFW). 2005a. Oregon Native Fish Status Report. Volume II. Assessment Methods and Population Results. Salem, Oregon.
[2] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*)
[3] USFWS. 2002. Chapter 2, Klamath River Recovery Unit, Oregon. 82 p. In: U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus)* Draft Recovery Plan. Portland, Oregon.
[4] Interior Redband Conservation Team (IRCT). 2016. A Conservation Strategy for Interior Redband (*Oncorhynchus mykiss* subsp.) in the states of California, Idaho, Montana, Nevada, Oregon, and Washington. 106 pp.
[5] Dambacher, J.M. and Jones, K.K., 2007. Benchmarks and patterns of abundance of redband trout in Oregon streams: a compilation of studies. Redband trout: resilience and challenge in a changing landscape. Oregon Chapter, American Fisheries Society, Corvallis, pp.47-55.
[6] NMFS.2016. DRAFT Recovery Plan for Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232. 120 pp.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			Reference
			Poor	Fair	Good	
1.4 Maintain or increase life history and genetic diversities	Genetic Integrity	%	< 99% unaltered	N/A	≥ 99% unaltered	Redband Trout: p.20 in IRCT 2016
	Genetic Redundancy	%	≥ 10% introgression	N/A	< 10% introgression	Redband Trout: p.20 in IRCT 2016
	Life History Diversity	count	Only 1 of many historical life history is represented	>1 historical life histories are represented	All historical life histories are represented	Redband Trout: p.20 in IRCT 2016
1.5 Maintain or increase spatial distributions as necessary *(i.e., expansion may not be appropriate goal for all species)*	% of Accessible Habitat Occupied	%	N/A	<80	≥80%	Coho: Table 4-1 in NMFS 2014
	% Historical populations still extant and not at risk		N/A	N/A	≥80%	Interim criteria and standards for Oregon salmon and steelhead, ODFW 2005[7] referenced in NMFS 2014[8].
	# New Local Populations Established in Suitable Habitat	count	0	1 – 2	3 – 5	Bull Trout: Recovery Criteria, in USFWS 2002, 2015[9], *(counts per core conservation area)*. Presence in new areas could be determined from archived water samples via eDNA.

[7] Oregon Department of Fish and Wildlife (ODFW). 2005a. Oregon Native Fish Status Report. Volume II. Assessment Methods and Population Results. Salem, Oregon.
[8] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*)
[9] USFWS. 2015. 2015. Recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). Portland, Oregon. xii + 179 pages.

Table C - 2. Proposed core performance indicators (CPIs) and published suitability thresholds for BIOLOGICAL INTERACTION related objectives.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
3.1 Eliminate or minimize adverse competitive or genetic consequences for native fish when carrying out conservation-oriented hatchery supplementation as needed.	Proportion of hatchery origin spawners (pHOS)	%	Low Natural Esc.: No limit High Natural Esc: > 50%	N/A	Low Natural Esc.: No limit High Natural Esc: < 50% SONCC Coho Recovery Crterion: <5%	Table 16 inCDFW and PacifiCorp 2014[10] Coho: Table 4-1 in NMFS 2014[11]
	Proportion of natural fish used as broodstock (pNOB)	%	<20 or >50	N/A	20-50	Table 16 inCDFW and PacifiCorp 2014
3.2 Minimize disease-related mortality by reducing vectors and factors known to lead to fish disease outbreaks	Presence of pathogen		C.shasta: > 10 spores / L *(Chinook)* > 5 spores / L *(coho)*	N/A	N/A	Hallett et al. 2012[12], thresholds for 40% mortality
	Prevalence of Infection		NA	NA	NA	NA
	Prevalence of Mortality		> 10% mortality of sentinel coho salmon juveniles at Beaver Creek confluence in the Klamath River during May and June	NA	≤ 10% mortality of sentinel coho salmon juveniles at Beaver Creek confluence in the Klamath River during May and June	Table 4-6 in NMFS 2014 (for *C. shasta* in coho)
3.3 Reduce impacts of exotic plants and animals species on native fish	Overall abundance	%	0-65% Reduction	≥ 65-75% Reduction	100% Reduction (eradication)	For brook trout, Table 2 in USGS and USFWS 2017[13], see also Buktenica et al. 2013[14]
	Habitat occupancy	count	> 2 non-native species present in watershed, and probability of dispersal high	1 – 2 non-native species present in watershed, and probability of dispersal low to moderate	0 non-native species present in watershed	Redband Trout Conservation Population Viability Index (CPVI) model proposed by Muhlfeld et al. 2015[15] Could be determined from archived water samples via eDNA.

[10] CDFW and PacifiCorp. 2014. Hatchery And Genetic Management Plan For Iron Gate Hatchery Coho Salmon. 163 pp.
[11] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*)
[12] Hallett, S.L., Ray, R.A., Hurst, C.N., Holt, R.A., Buckles, G.R., Atkinson, S.D. and Bartholomew, J.L., 2012. Density of the waterborne parasite, Ceratomyxa shasta, and biological effects on salmon. Applied and environmental microbiology, pp.AEM-07801. Available from: http://aem.asm.org/content/78/10/3724.full.pdf+html
[13] USGS and USFWS. 2017. Structured Decision Making for Conservation of Bull Trout (*Salvelinus confluentus*) in Long Creek, Klamath River Basin, South-Central Oregon. 40 pp. Available at: https://pubs.usgs.gov/of/2017/1075/ofr20171075.pdf
[14] Buktenica, M.W., Hering, D.K., Girdner, S.F., Mahoney, B.D. and Rosenlund, B.D., 2013. Eradication of nonnative Brook Trout with electrofishing and antimycin-A and the response of a remnant Bull Trout population. North American Journal of Fisheries Management, 33(1), pp.117-129.
[15] Muhlfeld, C.C., D.H. Bennett, and B. Marotz. 2001. Summer habitat use by Columbia River Redband in the Kootenai River drainage, Montana. North American Journal of Fisheries Management 21:223–235.

Table C - 3. Proposed core performance indicators (CPIs) and published suitability thresholds for HABITAT related objectives that are NOT species specific.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds: Poor	Published Suitability Thresholds: Fair	Published Suitability Thresholds: Good	References
4.1 Restore fish passage and re-establish channel and other habitat connectivity, particularly in high-value habitats (e.g., thermal refugia)	Number of fish passage barriers - Total *(inland fish)* - Downstream *(anadromous fish)*	Count	>8 ≥4	5 – 7 3 – 2	0 – 4 0 – 1	Table 4 in Fesenmeyer et al. 2013[16] *(subwatershed scale)* *See:* • California Passage Assessment Database (PAD) via CalFish • Oregon Fish Passage Barrier Standard Dataset via ODFW
	% total stream miles accessible *(anadromous fish)*	%	<30%	30-50%	50-90%	Table 4 in Fesenmeyer et al. 2013 *(indicator at subwatershed scale)*
	Ratio of current to historical stream miles accessible *(inland fish)*	%	<75%	75-90%	>90%	Table 4 in Fesenmeyer et al. 2013 *(indicator at subwatershed scale)*
4.2 Improve water temperatures and other local water quality conditions and processes for fish growth and survival	Temperature	ºC	OR TMDL: >20 ºC (incipent or instantaneous lethal limit for coldwater fish causing mortality over hours to days) CA TMDL: Monthly average at stateline > monthly Temperature Numeric Target <u>SPECIES:</u>	OR TMDL: 17.8-20 ºC (sub-lethal limit for coldwater fish associated with reduced performance that becomes lethal with long-term exposure over weeks to months) <u>SPECIES:</u>	OR TMDL: ≤ 17.8 ºC (below lethal and sub-lethal limits for coldwater fish) CA TMDL: Monthly average at stateline ≤ monthly Temperature Numeric Target <u>SPECIES:</u>	OR: Table 2-4 and 4-3 in ODEQ 2010[17] (threshold set for redband trout based on instantaneous or incipient lethal limits for cold-water fish (21ºC and over). CA: Table 5.3 in NCRWQCB 2010[18]

[16] Fesenmeyer, K. Henrery, R., and Williams, J. 2013. California Freshwater Conservation Success Index: An Assessment of Freshwater Resources in California, with focus on lands managed by the US Bureau of Land Management Version 1.0, December 2013. Trout Unlimited Science program. 45 pp. (Note: Spatial extent of indices encompass entire Klamath Basin in CA and OR; 5-point indicator scale lumped to fit into 3 categories).
[17] State of Oregon Dept. of Environmental Quality (ODEQ). 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP).
NCRWQCB. [18] 2010. Final staff report for the Klamath River total maximum daily loads (TMDLs) addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in California the proposed site specific dissolved oxygen objectives for the Klamath River in California, and the Klamath River and Lost River implementation plans.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
			Coho & Chinook: ≥ 20 ºC *(lethal to eggs)*, ≥ 25 ºC *(lethal to juveniles, adults)* Steelhead: ≥ 20 ºC *(lethal to eggs)*, ≥ 24 ºC *(lethal to juveniles, adults)* Bull trout: > 18 ºC *(limit for adult persistence)* Redband trout: >21 ºC *(not suitable for subadult and adult habitat use)* Suckers: < 5.5 ºC *(unsuitable for spawning)* Green sturgeon: > 23ºC *(complete mortality of embryos before hatch)* DISEASE: *C.shasta infection mortality rate*	Bull trout: 15 - 18 ºC *(limits adult distributions)* Chinook: 13 – 24 ºC *(suitable for rearing)* Bull trout: 12 – 20 ºC *(lower adult densities)* Redband trout: 0 – 10 and 18 – 21 ºC *(suitable for subadult and adult habitat use)* Suckers: 5.5 – 10 ºC *(suitable for spawning, but below peak spawning activity)* Green sturgeon: ≤ 11 and 19-23ºC *(detrimental to embryos)*	Coho: 16-17 ºC is considered good, <16 ºC is very good. Chinook: 13 ºC *(optimal rearing in streams)* >17 ºC *(optimal smoltification in estuary)* <15.5 ºC *(optimal for migration and spawning)* Bull trout: 4 – 10 ºC *(spawning)* 1 – 6 ºC *(egg incubation)* 4 – 4.5 ºC *(optimal fry growth)* 4 – 10 ºC *(optimal juvenile growth)* 4 – 12 ºC *(highest adult densities)* 10-12 ºC *(adult migration)* Redband trout: 10 – 18 ºC *(optimal for subadult and adult habitat use)*	SPECIES: Coho: Table 4-6 in NMFS 2014[19] , Carter 2005[20] *(lethality)*, Chinook: McCullough 1999[21], Carter 2005, Allen and Hassler 1986[22] Bull trout: Figure 1 in Buchanan and Gregory 1997[23] Redband Trout: Chandler 2003 *(subadults and adults habitat use)*[24] Green sturgeon: Moser et al. 2016[25]; Israel and Klimley 2008[26] Benson et al. 2007[27]

[19] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch)

[20] Carter, K. 2005. The effects of temperature on steelhead, coho salmon, and Chinook salmon biology and function by life stage: Implications for Klamath Basin TMDLs. Report for California Regional Water Quality Control Board, August 2005. More detailed thresholds per species and life stage which are consistent with TMDLs are available in reference.

[21] McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Prepared for the U.S. EPA. Region 10, Seattle, Washington. Published as EPA 910-R-99-010

[22] Allen, M.A. and T.J. Hassler, 1986. Species profiles: life history and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) – Chinook salmon. U.S. Fish and Wildlife Service Biological Report 82 (11.49). U.S. Army Corp of Engineers, TR EL-82-4.

[23] Buchanan, D.V. and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Proceedings of the Friends of the Bull Trout Conference. Calgary, Alberta, Canada.

[24] Chandler, J.A., ed. 2003. Redband Trout and Bull Trout Associated with the Hells Canyon Complex. Idaho Power Company Technical Report Appendix E.3.1-7 Hells Canyon Complex FERC No. 1971. Available at: https://docs.idahopower.com/pdfs/relicensing/hellscanyon/hellspdfs/techappendices/Aquatic/e31_07_ch01.pdf

[25] Moser, M.L., Israel, J.A., Neuman, M., et al. 2016. Biology and life history of green sturgeon (Acipenser medirostris Ayres, 1854): state of the science. Journal of Applied Ichthyology, 32, pp.67-86.

[26] Israel, J.A. and Klimley, A.P. 2008. DRERIP Life History Conceptual Model for North American Green Sturgeon (*Acipenser medirostris*). Available from: http://www.dfg.ca.gov/erp/cm_list.asp

[27] Benson, R.L., Turo, S. and McCovey Jr, B.W., 2007. Migration and movement patterns of green sturgeon (Acipenser medirostris) in the Klamath and Trinity rivers, California, USA. Environmental Biology of Fishes, 79(3-4), pp.269-279. Available from: http://logontowww.yuroktribe.org/departments/fisheries/documents/KlamathTrinityGreenSturgeonPublication2006_000.pdf

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
			Chinook: > 18 ºC *(85 – 100% mortality)* Coho: > 18 ºC *(80 – 90% mortality)*	Pacific lamprey: 10 – 13 and 17 – 18 ºC *(suitable for spawning)* DISEASE: *C.shasta infection mortality rate* Chinook: 13 - 18 ºC *(65 – 85% mortality)* Coho: 13 - 18 ºC *(65 – 80% mortality)*	Green sturgeon: 14 – 17 ºC *(optimal embryonic development)* 19 – 24 ºC *(optimal juvenile growth)* 10 – 12 ºC *(triggers fall outmigration on the Klamath River)* Suckers: 5.5 – 19 ºC *(suitable for spawning)* *> 10* ºC *(peak Lost River sucker spawning)* *≥ 12* ºC *(peak shortnose sucker spawning)* 14 – 22 ºC *(optimal larval survival)* Pacific lamprey: 14 – 15 ºC *(optimal for spawning)* Eulachon:4 – 10 ºC *(optimal for migration and spawning)* DISEASE: *C.shasta infection mortality rate*	Suckers: NRC 2004 (p194)[28] Cooperman et al. 2010[29] Hewitt et al. 2012[30], 2015[31] Pacific lamprey: CalFish 2018[32] Eulachon: Emmett et al 1991[33] Disease: Figure 3 in Ray et al. 2012[34] (*C. shasta*)

[28] National Research Council (NRC), 2004. Endangered and threatened fishes in the Klamath River Basin: causes of decline and strategies for recovery. National Academies Press.

[29] Cooperman, M.S., Markle, D.F., Terwilliger, M. and Simon, D.C., 2009. A production estimate approach to analyze habitat and weather effects on recruitment of two endangered freshwater fish. Canadian Journal of Fisheries and Aquatic Sciences, 67(1), pp.28-41.

[30] Hewitt, D. A., E. C. Janney, B. S. Hayes, and A. C. Harris. 2012. Demographics and run timing of adult Lost River Deltistes luxatus and Shortnose *Chasmistes brevirostris* suckers in Upper Klamath Lake, Oregon, 2011. U.S. Geological Survey, Open-File Report 2012-1193, Reston, Virginia.

[31] Hewitt, D.A., E.C. Janney, B.S. Hayes, and A.C Harris. 2015. Status and trends of adult Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) sucker populations in Upper Klamath Lake, Oregon, 2014: U.S. Geological Survey Open-File Report 2015-1189, 36

[32] CalFish Species Profiles: Pacific Lamprey http://www.calfish.org/FisheriesManagement/SpeciesPages/PacificLamprey.aspx (original references missing)

[33] Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast Estuaries, Volume II: Species life history summaries. ELMR Report Number 8, Strategic Assessment Branch, NOS/NOAA, referenced in http://www.calfish.org/FisheriesManagement/SpeciesPages/Eulachon.aspx

[34] Ray, R.A., Holt, R.A. and Bartholomew, J.L., 2012. Relationship between temperature and Ceratomyxa shasta–induced mortality in Klamath River salmonids. Journal of Parasitology, 98(3), pp.520-526. Available from: the following link.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
					Chinook: < 13 ºC *(< 65% mortality)* Coho: < 13 ºC *(< 65% mortality)*	
	Dissolved Oxygen	mg/L or % saturation	OR: < 4.0 mg/L Upper Klamath Lake outlet or < 6.0 downstream of Keno Dam OR in Lost River year-round <11 mg/L or <95% saturation downstream of Keno Dam during salmonid and trout spawning period (Jan 1 – May 15) CA: Monthly mean and minimum <85% saturation at stateline and below Salmon River SPECIES: Chinook: < 1.6 mg / L *(eggs, lethal)* < 4.5 mg / L *(juvenile rearing)* Steelhead: < 5.0 mg/L *(juvenile rearing)* Suckers: < 4 mg / L	SPECIES: Steelhead: 6.5 – 7.0 mg/L *(juvenile rearing)* Bull Trout & Redband Trout: >38 % saturation (at 0 – 11 ºC) >39 - 54% saturation (at 11 – 28 ºC) *(subadults and adults)* Suckers: 4 - 6 mg / L	OR: ≥ 4.0 mg/L Upper Klamath Lake outlet or ≥ 6.0 downstream of Keno Dam OR in Lost River year-round ≥11 mg/L or ≥95% saturation downstream of Keno Dam during salmonid and trout spawning period (Jan 1 – May 15) CA: Monthly mean and minimum ≥85% saturation at stateline and below Salmon River SPECIES: Chinook: 100% saturation *(eggs)* Coho: > 8 mg/L *(spawning)*, 4 – 9 mg/L *(juvenile rearing)* Steelhead: > 7.0 mg/L Bull Trout & Redband Trout: >76% saturation (at 0 – 15 ºC) >77 - 96% saturation (at 16 – 28 ºC) *(subadults and adults)* Green sturgeon: > 6.5 mg / L	OR: Table 2-3, Section 3.3.2.1 in ODEQ 2010 CA: Table 5.1 in NCRWQCB 2010 See also Martin et al. 1998[35] for lower lethal thresholds for suckers, which are below the TMDL thresholds. Table 4-6 in NMFS 2014[36] (for coho, thresholds consistent with those in TMDL). SPECIES: Chinook: Allen and Hassler 1986[37] Coho: NMFS 2001 [38] Steelhead: NMFS 2001 Bull Trout and Redband Trout: Chandler 2003 *(subadults and adults habitat use)*[39]

[35] Martin, B.A. and Saiki, M.K., 1999. Effects of ambient water quality on the endangered Lost River sucker in Upper Klamath Lake, Oregon. Transactions of the American Fisheries Society, 128(5), pp.953-961.
[36] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch)
[37] Allen, M.A. and T.J. Hassler, 1986. Species profiles: life history and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) – Chinook salmon. U.S. Fish and Wildlife Service Biological Report 82 (11.49). U.S. Army Corp of Engineers, TR EL-82-4.
[38] NMFS. 2001. The Effects of Summer Dams on Salmon and Steelhead in California COasta Watersheds and Recommendations for Mitigating Their Impacts. National Marine Fisheries Service, Southwest Region – Santa Rosa Field Office. Available from: http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/c8ef5608-8b41-41b3-bbb7-449bd805399d
[39] Chandler, J.A., ed. 2003. Redband Trout and Bull Trout Associated with the Hells Canyon Complex. Idaho Power Company Technical Report Appendix E.3.1-7 Hells Canyon Complex FERC No. 1971. Available at: https://docs.idahopower.com/pdfs/relicensing/hellscanyon/hellspdfs/techappendices/Aquatic/e31_07_ch01.pdf

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
					Suckers: >6 mg / L	Green sturgeon: Moser et al. 2016[40] Suckers: Burdick et al. 2008 (citing Loftus 2001)[41]
	pH	unitless	OR: <6.5 or > 9.0 at the Upper Klamath Lake outlet, downstream of Keno Dam, or in Lost River SPECIES: NMFS (Coho): >8.5	OR: N/A SPECIES: NMFS (Coho): 8.25 – 8.5	OR: 6.5 – 9.0 at the Upper Klamath Lake outlet, downstream of Keno Dam, or in Lost River SPECIES: NMFS (Coho): <8.25	OR: Section 2.2.3 in ODEQ 2010[42] Table 4-6 in NMFS 2014[43] (for coho
	Total Phosphorous (Average daily concentration)	mg/L	OR: > Target Concentrations at Non-Point Sources (flow-weighted) UKL (baseline): 0.024 Lost River Diversion 0.029 Klamath Straits Drain 0.035 Other NPS: 0.035 Springs (natural): 0.069 CA: >Target Monthly Concentrations Stateline: 0.023 (Oct) to 0.030 (April) Mainstem Downstream of Salmon River: 0.021 (Jan) – 0.027 (Nov)	N/A	OR: < Target Concentrations at Non-Point Sources (flow-weighted) UKL (baseline): 0.024 Lost River Diversion 0.029 Klamath Straits Drain 0.035 Other NPS: 0.035 Springs (natural): 0.069 CA: <Target Monthly Concentrations Stateline: 0.023 (Oct) to 0.030 (April) Mainstem Downstream of Salmon River: 0.021 (Jan) – 0.027 (Nov)	OR: Table 2-9 in ODEQ 2010 CA: Table 5.9, 5.14 in NCRWQCB 2010
	Total Nitrogen (Average daily concentration)	mg/L	OR: > Target Concentrations at Non-Point Sources (flow-weighted) UKL (baseline): 0.31 Lost River Diversion 0.37 Klamath Straits Drain 0.45 Other NPS: 0.45	N/A	OR: < Target Concentrations at Non-Point Sources (flow-weighted) UKL (baseline): 0.31 Lost River Diversion 0.37 Klamath Straits Drain 0.45 Other NPS: 0.45	OR: Table 2-9 in ODEQ 2010 CA: Table 5.9, 5.14 in NCRWQCB 2010

[40] Moser, M.L., Israel, J.A., Neuman, M., Lindley, S.T., Erickson, D.L., McCovey Jr, B.W. and Klimley, A.P., 2016. Biology and life history of green sturgeon (Acipenser medirostris Ayres, 1854): state of the science. Journal of Applied Ichthyology, 32, pp.67-86.

[41] Burdick, S.M., Hendrixson, H.A. and VanderKooi, S.P., 2008. Age-0 Lost River sucker and shortnose sucker nearshore habitat use in Upper Klamath Lake, Oregon: a patch occupancy approach. Transactions of the American Fisheries Society, 137(2), pp.417-430.

[42] State of Oregon Dept. of Environmental Quality (ODEQ). 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP).

[43] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch)

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
			Springs (natural): 0.31 CA: >Target Monthly Concentrations Stateline: 0.252 (Aug) to 0.395 (April) Mainstem Downstream of Salmon River: 0.173 (Jan) – 0.242 (Oct)		Springs (natural): 0.31 CA: <Target Monthly Concentrations Stateline: 0.252 (Aug) to 0.395 (April) Mainstem Downstream of Salmon River: 0.173 (Jan) – 0.242 (Oct)	
	Nuisance Phytoplankton (chlorophyll-a)	mg/m^2	OR: < 0.015 mg/L at the Upper Klamath Lake outlet, downstream of Keno Dam, or in Lost River CA: < 150 mg of chlorophyll-a $/m^2$ below the Salmon River	N/A	OR: ≥ 0.015 mg/L at the Upper Klamath Lake outlet, downstream of Keno Dam, or in Lost River CA: ≥150 mg of chlorophyll-a $/m^2$ below the Salmon River	OR: Section 3.3.2.3 in ODEQ 2010 CA: Table 5.1 in NCRWQCB 2010[44]
4.3 Enhance and maintain community and food web diversity supporting native fish	Stream Condition Index (via SWAMP macroinvertebrate monitoring program data)	Unitless	Likely to be intact ≥30th percentile (CSCI ≥ 0.92)	Possibly altered 30th– 10th percentile (CSCI ≥ 0.79) Likely to be altered 1st–10th percentile (CSCI ≥ 0.63)	Very likely to be altered <1st percentile (CSCI < 0.63)	Mazor et al. 201545
	Aquatic Vertebrate IBI	Unitless	< 37	N/A	≥62	EPA 2005 (Mountain Region)46
	Macroinvertebrate IBI	Unitless	< 57	N/A	≥71	EPA 2005 (Mountain Region)
	Aq Macroinverts (EPT)	Unitless	<19	19-25	>25	Table 4-6 in NMFS 2014 (for coho)
	Aq Macroinverts (Richness)	Unitless	<31	31-40	>40	Table 4-6 in NMFS 2014 (for coho)
	Aq Macroinverts (B-IBI)	Unitless	< 60.1	60.1-80	>80	Table 4-6 in NMFS 2014 (for coho)

[44] NCRWQCB. 2010. Final staff report for the Klamath River total maximum daily loads (TMDLs) addressing temperature, dissolved oxygen, nutrient, and microcystin impairments in California the proposed site specific dissolved oxygen objectives for the Klamath River in California, and the Klamath River and Lost River implementation plans.

[45] Mazor, R.D., Rehn, A.C., Ode, P.R., Engeln, M., Schiff, K.C., Stein, E.D., Gillett, D.J., Herbst, D.B. and Hawkins, C.P., 2016. Bioassessment in complex environments: designing an index for consistent meaning in different settings. Freshwater Science, 35(1), pp.249-271.

[46] Stoddard, J. L., D. V. Peck, S. G. Paulsen, et al. 2005. An Ecological Assessment of Western Streams and Rivers. Environmental Monitoring and Assessment Program (EMAP). EPA 620/R-05/005, U.S. Environmental Protection Agency, Washington, DC.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
4.4 Reduce fish mortality due to entrainment, scour, stranding	Miles canals	mi	≥ 20	5-20	1-5	Table 4, Fesenmeyer et al. 2013[47] *(indicator at subwatershed scale)*
	Diversions per stream mile	count / mi	>1	1-0.4	1-0.4	Table 4 in Fesenmeyer et al. 2013 *(indicator at subwatershed scale)*

[47] Fesenmeyer, K. Henrery, R., and Williams, J. 2013. California Freshwater Conservation Success Index: An Assessment of Freshwater Resources in California, with focus on lands managed by the US Bureau of Land Management Version 1.0, December 2013. Trout Unlimited Science program. 45 pp. (Note: Spatial extent of indices encompass entire Klamath Basin in CA and OR; 5-point indicator scale lumped to fit into 3 categories).

Table C - 4. Proposed core performance indicators (CPIs) and published suitability thresholds for HABITAT related objectives that ARE species specific. Note that aspects of habitat related to water quality are addressed in Table C - 3.

Sub-Objective	Species	Core Performance Indicator	Units	Published Suitability Thresholds			References
				Poor	Fair	Good	
4.5 Enhance and maintain estuary, mainstem, tributary, lake and wetland habitats for all freshwater life stages and life histories of resident and anadromous fish	Coho Salmon	Water Depth	cm	13.72 – 62.48 (fry rearing) >22.25 (juvenile rearing) 14.33 – 62.18 *(spawning)*	13.72 – 20.42 and 49.68 – 62.48 *(fry rearing)* 22.25 – 39.62 *(juvenile rearing)* 14.33 – 20.73 and 53.95 – 62.18 *(spawning)*	20.42 – 49.68 (fry rearing) > 39.62 *(juvenile rearing)* 20.42 – 53.95 *(spawning)*	Hampton et al. 1997[48] *(thresholds derived by dividing Habitat Suitability Criteria curves into thirds)*
		Water Velocity	m/s	> 0.08 (fry rearing) > 0.26 (juvenile rearing) 0.09 – 0.64 *(spawning)*	0.04 – 0.08 (fry rearing) 0.08 – 0.26 *(juvenile rearing)* 0.09 – 0.15 and 0.52 – 0.64 *(spawning)*	0 – 0.04 (fry rearing) 0 – 0.08 *(juvenile rearing)* 0.15 – 0.52 *(spawning)*	Hampton et al. 1997 *(thresholds derived by dividing Habitat Suitability Criteria curves into thirds)*
		Pool Depths	ft	< 3-3.3 ft	3-3.3 ft	>3.3 ft.	Table 4-6 in NMFS 2014[49] (for coho)
		Pool Frequency (length)	%	< 41-50%	41-50%	>50%	Table 4-6 in NMFS 2014 (for coho)
		Pool Frequency (area)	%	< 21-35%	21-35%	>35%	Table 4-6 in NMFS 2014 (for coho)
		D50 (median particle size)	cm	< 5.1 - >11.0	5.1-6.0 & 9.5-11.0	6.0-9.5	Table 4-6 in NMFS 2014 (for coho)
		% Fines	%	N/A	N/A	< 20 (spawning), <15 *(egg, fry survival)*	NMFS 2001[50]
	Chinook Salmon	Substrate size	cm	N/A	N/A	1.3 – 10.2 *(spawning)*	Allen and Hassler 1986[51]
		% Fines (< 6.4 mm)	%	>40 (emergence)	30 – 40 (emergence)	< 30 (emergence) <5 (spawning)	Bjornn and Reiser 1991, cited in NMFS 2001

[48] Hampton, M., Payne, T.R>, and Thomas, J.A. 1997. Microhabitat Suitability Criteria for Anadromous Salmonids of the Trinity River. USDOI and USFWS Coastal California Fish and Wildlife Office, 1125 16th Street, Room 209, Arcata, California 95521. Available from: https://www.fws.gov/arcata/fisheries/reports/technical/Microhabitat_Suitability_Criteria_for_Anadromous_Salmonids_of_the_TR.pdf
[49] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch)
[50] NMFS. 2001. The Effects of Summer Dams on Salmon and Steelhead in California COasta Watersheds and Recommendations for Mitigating Their Impacts. National Marine Fisheries Service, Southwest Region – Santa Rosa Field Office. Available from: http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/c8ef5608-8b41-41b3-bbb7-449bd805399d
[51] Allen, M.A. and T.J. Hassler, 1986. Species profiles: life history and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) – Chinook salmon. U.S. Fish and Wildlife Service Biological Report 82 (11.49). U.S. Army Corp of Engineers, TR EL-82-4.

Sub-Objective	Species	Core Performance Indicator	Units	Published Suitability Thresholds			References
				Poor	Fair	Good	
		Water Depth	cm	< 6.4 or > 85.95 (fry rearing) (a) < 13.11 *(juvenile rearing) (a)* < 14.33 or >77.72 *(spawning) (a)*	6.40 – 14.63 and 58.22-85.95 *(fry rearing) (a)* 13 – 24 *(juvenile rearing) (a)* 14.33 – 20.73 and 62.79 – 77.72 *(spawning) (a)*	14.63 – 58.22 (fry rearing) (a) >24 (juvenile rearing) (a) 20.73 – 62.79 *(spawning) (a)* ≥ 24 (migration & spawning) (b) 30 – 122 *(juvenile rearing) (b)*	(a) Hampton et al. 1997 (thresholds derived by dividing Habitat Suitability Criteria curves into thirds) (b) Allen and Hassler 1986
		Water Velocity	m/s	> 0.15 (fry rearing) (a) > 0.40 (juvenile rearing) (a) 0.20 – 0.77 (spawning) (a)	0.08 – 0.15 (fry rearing) (a) 0.00 – 0.02 and 0.25 – 0.40 *(juvenile rearing) (a)* 0.20 – 0.29 and 0.61 – 0.77 *(spawning) (a)*	0.00 – 0.08 (fry rearing) (a) 0.02 – 0.25 (juvenile rearing) (a) 0.29 – 0.61 (spawning) (a) ≤ 2.4 (adult upstream migration, sustained current maximum) (b) ≤ 6.1 *(adult upstream migration, obstacle current maximum) (b)* 0.3 – 0.91 *(spawning) (b)* 0.06 – 0.24 *(juvenile rearing) (b)*	(a) Hampton et al. 1997 (thresholds derived by dividing Habitat Suitability Criteria curves into thirds) (b) Allen and Hassler 1986
	Steelhead	Substrate Size	cm	N/A	N/A	1.3 – 11.7 *(spawning)*	Bjornn 1979, cited in NMFS 2001[52]
		% Fines (< 6.4 mm)	%	>20 *(embryo survival)*	20 – 25 *(embryo survival)*	<20 *(embryo survival)*	Bjornn 1979, cited in NMFS 2001
		Water Depth	cm	< 10.46 or > 44.20 *(fry rearing)* < 34.14 *(juvenile rearing)* < 3.96 *(juvenile overwintering)* < 18.59 or >47.55 *(spawning)* < 32 *(holding)*	10.36 – 14.02 and 34.14 – 44.20 *(fry rearing)* 34.14 – 47.24 and 98.45 – 118.87 *(juvenile rearing)* 3.96 – 7.62 *(juvenile overwintering)* 18.59 – 23.77 and 41.15 – 47.55 *(spawning)* 32.00 – 49.38 *(overwintering)*	14.02 – 34.14 (fry rearing) 47.24 – 98.45 (juvenile rearing) *> 7.62 (juvenile overwintering)* 23.77 – 41.15 *(spawning)* > 49.38 *(spawning)*	Hampton et al. 1997[53] (thresholds derived by dividing Habitat Suitability Criteria curves into thirds)

[52] NMFS. 2001. The Effects of Summer Dams on Salmon and Steelhead in California COasta Watersheds and Recommendations for Mitigating Their Impacts. National Marine Fisheries Service, Southwest Region – Santa Rosa Field Office. Available from: http://s3-us-west-2.amazonaws.com/ucldc-nuxeo-ref-media/c8ef5608-8b41-41b3-bbb7-449bd805399d

[53] Hampton, M., Payne, T.R>, and Thomas, J.A. 1997. Microhabitat Suitability Criteria for Anadromous Salmonids of the Trinity River. USDOI and USFWS Coastal California Fish and Wildlife Office, 1125 16th Street, Room 209, Arcata, California 95521. Available from: https://www.fws.gov/arcata/fisheries/reports/technical/Microhabitat_Suitability_Criteria_for_Anadromous_Salmonids_of_the_TR.pdf

Sub-Objective	Species	Core Performance Indicator	Units	Published Suitability Thresholds			References
				Poor	Fair	Good	
		Water Velocity	m/s	> 0.26 (fry rearing) 0.02 – 0.84 (juvenile rearing) 0.01 – 0.45 (juvenile overwintering) 0.14 – 0.71 (spawning) 0.17 – 0.94 (holding)	0.20 – 0.26 (fry rearing) 0.02 – 0.05 and 0.61 – 0.84 *(juvenile rearing)* 0.34 – 0.46 *(juvenile overwintering)* 0.14 – 0.20 and 0.61 – 0.71 *(spawning)* 0.17 – 0.29 and 0.77 – 0.0.96 *(holding)*	0 – 0.20 (fry rearing) 0.05 – 0.61 *(juvenile rearing)* 0.01 – 0.34 *(juvenile overwintering)* 0.20 – 0.61 *(spawning)* 0.29 – 0.77 *(holding)*	Hampton et al. 1997 (thresholds derived by dividing Habitat Suitability Criteria curves into thirds)
	Bull Trout	Substrate Size	cm	≥ 7.63 (cobble and boulder) *(spawning)* ≤ 2.54 (pebble and sand) *(subadult and adult rearing)*	<0.64 (sand) and 5.09 – 7.62 (large gravel) *(spawning)* 2.55 – 7.62 (small and large gravel) *(subadult and adult rearing)*	0.65 – 2.54 (pebble) and 2.55 – 5.08 (small gravel) *(spawning)* ≥ 7.63 (boulder and cobble) *(subadult and adult rearing)*	Anglin et al. 2008[54] (Table 1 and Figure 20)*(spawning)* (Table 1 and Figures 30, 31) *(subadult and adult rearing)*
		Water Depth	cm	≥ 100 (spawning)	39 - 99 (spawning) 50 – 150 and 250 – 850 (subadults and adults habitat use)	≤ 40 (spawning) 150 – 250 (subadults and adults habitat use)	Anglin et al. 2008 (Figure 20)*(spawning)* Chandler 2003 (subadults and adults habitat use)[55]
		Water Velocity	m/s	≥ 0.8 (spawning, water column)	0.2 – 0.6 (spawning, water column) 0 – 0.15, 0.45 – 2.55 (subadults and adults, water column) 0.3 – 2.9 *(subadults and adults, bottom)*	≤ 0.2 (spawning, water column) 0.15 to 0.45 (subadults and adults, water column) 0 to 0.3 *(subadults and adults, bottom)*	Anglin et al. 2008 (Figure 20)*(spawning)*[56] Chandler 2003 (subadults and adults habitat use), supported by similar values in Anglin et al. 2008 (Figures 28, 29)
		Substrate Size	cm	< 2 and > 6 *(spawning)*	N/A	2 - 6 (spawning)	Muhlfeld 2002[57] *(spawning)*

[54] Anglin, D.R>, Gallion, D.G., Barrows, M. et al. 2008. Bull Trout Distribution, Movements and Habitat Use in the Walla Walla and Umatilla River Basins. 2004 Annual Progress Report. Prepared by the USDOI and USFWS Columbia River Fisheries Program Office. Available at: https://www.fws.gov/columbiariver/publications/BT_Annual_Progress_Report_2004_FINAL.pdf
[55] Chandler, J.A., ed. 2003. Redband Trout and Bull Trout Associated with the Hells Canyon Complex. Idaho Power Company Technical Report Appendix E.3.1-7 Hells Canyon Complex FERC No. 1971. Available at: https://docs.idahopower.com/pdfs/relicensing/hellscanyon/hellspdfs/techappendices/Aquatic/e31_07_ch01.pdf
[56] Anglin, D.R>, Gallion, D.G., Barrows, M. et al. 2008. Bull Trout Distribution, Movements and Habitat Use in the Walla Walla and Umatilla River Basins. 2004 Annual Progress Report. Prepared by the USDOI and USFWS Columbia River Fisheries Program Office. Available at: https://www.fws.gov/columbiariver/publications/BT_Annual_Progress_Report_2004_FINAL.pdf
[57] Muhlfeld, C.C., 2002. Spawning characteristics of redband trout in a headwater stream in Montana. North American Journal of Fisheries Management, 22(4), pp.1314-1320.

Sub-Objective	Species	Core Performance Indicator	Units	Published Suitability Thresholds			References
				Poor	Fair	Good	
	Redband Trout	Water Depth	cm	0 – 10 and 51 - 100 *(spawning)*	11-20 and 31 - 50 *(spawning)* 0 – 150 and 150 – 1000 *(subadults and adult habitat use)*	21 - 30 (spawning) 150 – 250 (subadults and adult habitat use)	Muhlfeld 2002 *(spawning)* Chandler 2003 (subadults and adults habitat use)[58]
		Water Velocity	m/s	0-0.2 and 0.71 - 1 *(spawning)*	0.21 – 0.4 (spawning) 0 – 0.15, 0.30 – 3.15 (subadults and adults, water column)	0.41 – 0.70 (spawning) 0.15 – 0.30 (subadults and adults, water column)	Muhlfeld 2002 *(spawning)* Chandler 2003 *(subadults and adults habitat use)*
	Pacific Lamprey	Substrate Size	cm	≥ 1.7 (large gravel to bedrock) *(ammocoetes)*	0.9 – 1.6 (small gravel) *(ammocoetes)*	< 0.1 – 0.8 (fines) *(ammocoetes)*	Figure 5 in Stone and Barndt 2005
		Water Depth	cm	(a) < 60 (ammocoetes)	(a) 60 – 65 and 75 – 80 *(ammocoetes)*	(a) 65 – 75, (b) 40 – 50 *(ammocoetes)* 30 – 400 *(spawning)*	(a) Figure 3 in Stone and Barndt 2005[59] (b) Q3 in Luzier et al. 2009[60]
		Water Velocity	cm / s	> 40 (ammocoetes) > 180 (<6 f/s) *(adult migration) (higher velocities inhibit mobility past obstacles)*	10 – 40 (ammocoetes)	< 10 – -10 *(ammocoetes)* 50 – 100 (spawning) < 180 (<6 f/s) *(adult migration) (higher velocities inhibit mobility past obstacles)*	Figure 4 in Stone and Barndt 2005 (ammocoetes; negative velocities indicate reverse flow or eddy environments) Q3 in Luzier et al. 2009 *(spawning)* CalFish 2018[61] (adult migrants)
	Lost River and	Lake Level	m / ft	≤1,261.87 m / 4,140.0 ft *(low larval survival)*	1,261.87 m / 4,140.0 ft to 1,262.48 m / 4,142.0 ft *(intermediate larval survival)*	≥1,262.48 m / 4,142.0 ft *(high larval survival)*	Figure 6 in Markle and Dunsmoor 2007[62]

[58] Chandler, J.A., ed. 2003. Redband Trout and Bull Trout Associated with the Hells Canyon Complex. Idaho Power Company Technical Report Appendix E.3.1-7 Hells Canyon Complex FERC No. 1971. Available at: https://docs.idahopower.com/pdfs/relicensing/hellscanyon/hellspdfs/techappendices/Aquatic/e31_07_ch01.pdf
[59] Stone, J. and Barndt, S., 2005. Spatial distribution and habitat use of Pacific lamprey (Lampetra tridentata) ammocoetes in a western Washington stream. Journal of Freshwater Ecology, 20(1), pp.171-185.
[60] Luzier, C.W. and 7 coauthors. 2009. Proceedings of the Pacific Lamprey Conservation Initiative Work Session – October 28-29, 2008. U.S. Fish and Wildlife Service, Regional Office, Portland, Oregon, USA
[61] CalFish Species Profiles: Pacific Lamprey http://www.calfish.org/FisheriesManagement/SpeciesPages/PacificLamprey.aspx (original references missing)
[62] Markle, D.F. and Dunsmoor, L.K., 2007. Effects of habitat volume and fathead minnow introduction on larval survival of two endangered sucker species in Upper Klamath Lake, Oregon. Transactions of the American Fisheries Society, 136(3), pp.567-579.

Sub-Objective	Species	Core Performance Indicator	Units	Published Suitability Thresholds			References
				Poor	Fair	Good	
	Shortnose Sucker	% Days with High-Wind Events (>16 km / h)	%	> 30	N/A	< 30	Cooperman et al. 2010[63] (high winds resuspend detrimental bottom sediments)
		Water Depth	cm	N/A	N/A	10 – 50 cm *(larvae)* 120 – 200 cm *(juveniles)* > 200 cm *(adults)* (stream spawners) 11 – 50 cm (Lost River sucker) 20 – 60 cm *(shortnose sucker)* *(lakeshore spawners)* 30 – 110 cm *(Lost River sucker)*	USFWS 2012 (larvae, juveniles, adults) Buchanan et al. 2011 *(spawners)*
		Water Velocity	m/s	N/A	N/A	Stream spawners: 0.1 – 0.85 (Lost River sucker) 0.80 – 1.20 *(shortnose sucker)*	Buchanan et al. 2011[64]
	Green Sturgeon	Water Depth (pools)	m	0-4 and ≥10	5-7	8-9	Moser et al. 2016[65] and Wyman et al. 2017[66] *(both holding & spawning)*
		Water Velocity	cm/s	< 40 or > 130	50 – 80 or 110 – 112	80 - 110	Figure 5 in Wyman et al. 2017 *(spawning)*
		Discharge	m^3/s	N/A	< 100	100 – 200 (triggers fall outmigration)	Benson et al. 2007[67] *(outmigrating)*
	Eulachon	Water Depth	m	N/A	N/A	0.07 – 7.6 m *(spawning)*	NMFS 2016[68]

[63] Cooperman, M.S., Markle, D.F., Terwilliger, M. and Simon, D.C., 2009. A production estimate approach to analyze habitat and weather effects on recruitment of two endangered freshwater fish. Canadian Journal of Fisheries and Aquatic Sciences, 67(1), pp.28-41.

[64] Buchanan, D., M. Buettner, T. Dunne, and G. Ruggerone. 2011. Scientific assessment of two dam removal alternatives on resident fish. Klamath River Expert Panel Final Report prepared for the Secretarial Determination.

[65] Moser, M.L., Israel, J.A., Neuman, M., Lindley, S.T., Erickson, D.L., McCovey Jr, B.W. and Klimley, A.P., 2016. Biology and life history of green sturgeon (Acipenser medirostris Ayres, 1854): state of the science. Journal of Applied Ichthyology, 32, pp.67-86.

[66] Wyman, M.T., Thomas, M.J., McDonald, et al. 2017. Fine-scale habitat selection of green sturgeon (*Acipenser medirostris*) within three spawning locations in the Sacramento River, California. Canadian Journal of Fisheries and Aquatic Sciences, 75(5), pp.779-791.

[67] Benson, R.L., Turo, S. and McCovey Jr, B.W., 2007. Migration and movement patterns of green sturgeon (Acipenser medirostris) in the Klamath and Trinity rivers, California, USA. Environmental Biology of Fishes, 79(3-4), pp.269-279. Available from: http://logontowww.yuroktribe.org/departments/fisheries/documents/KlamathTrinityGreenSturgeonPublication2006_000.pdf

[68] NMFS. 2016. Recovery Plan for Eulachon (Thaleichthys pacificus). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232. 120 pp.

Sub-Objective	Species	Core Performance Indicator	Units	Published Suitability Thresholds			References
				Poor	Fair	Good	
		Water Velocity	cm/s	N/A	N/A	Spawners: ≤ 40 (higher flows limit upstream migration)	NMFS 2011[69]
		Salinity	ppt	Eggs: ≥11 (detach and die above threshold)	Eggs: > 5.5 to <11 (survival to hatch <10%)	Eggs: 0 – 5.5 (survival to hatch 21-25%)	Gordon et al. 2012[70], citing Beak 1995.

[69] NMFS. 2011. Critical Habitat for the Southern Distinct Population Segment of Eulachon: Final Biological Report. 59 pp. Available from: http://www.westcoast.fisheries.noaa.gov/protected_species/eulachon/eulachon_critical_habitat.html

[70] Gordon, M.R., A. Lewis, K. Ganshorn, and D. McLeay. 2012. Present status, historical causes of population decline, and potential for restoration of the Kitimat River eulachon (Thaleichthys pacificus). Prepared for the Haisla Nation Council (Kitamaat Village, BC) by M.R. Gordon & Associates Ltd., Ecofish Research Ltd., and McLeay Environmental Ltd. 44 pp.

Table C - 5. Proposed core performance indicators (CPIs) and published suitability thresholds for FLUVIAL AND GEOMORPHIC PROCESS related objectives.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
5.1 Increase and maintain coarse sediment recruitment and transport processes	Flow rate capable of mobilizing coarse sediment to improve spawning gravels (% days / year?)	cfs	0 – 5,000 cfs *(immobile to stable bed)*	5,000 – 11,250 cfs *(surface to deep flushing of surface or in-filled fine sediment)*	11,250 – 15,000 *(movement or individual armour layer particles, including gravels, up to reworking of armor and substrate layers)*	Table 4 in USFWS 2016[71] *(values assessed for the Klamath River downstream of Iron Gate dam, thresholds may vary by reach beyond these general classifications)*
5.2 Increase channel and floodplain dynamics and interconnectivity	Acres of seasonally inundated wetland	NA	NA	NA	NA	No benchmarks specified. Salwasser et al. 2002[72] proposes setting benchmarks as a % area relative to historical extent, or as % increases per from current baselines to the maximum extent considered feasible, where adequate historical data is not available. For the Klamath Basin, recent historical extent of wetlands from infrared imaging in 1982 are available from the USFWS via: https://www.fws.gov/wetlands/data/mapper.html
	Area available for channel migration which can be expressed as the Freedom Space	m^2 or km^2	Freedom space < L_{min} Space *Where L_{min} represents the minimal space for a river system to operate, i.e., for hydrogeomorphic and ecological processes to proceed.* $L_{min} = M_{50}$ area (short-term	Freedom space ≥ L_{min} Space	Freedom space ≥ $L_{min} + L_{func}$ Space *Where the L_{func} space represents a wider zone beyond the L_{min} space, a corridor which is necessary for essential fluvial processes to operate for full floodplain development or.* $L_{func} = M_{floodplain}$ area (space that will be occupied by the river in the	Biron et al. 2014[73] See also Kondolf 2012[74]

[71] USFWS. Response to Request for Technical Assistance – Sediment Mobilization and Flow History in Klamath River below Iron Gate Dam. Response from USFWS Arcata Office to USDOI. 28 pp. Available at: https://www.fws.gov/arcata/fisheries/reports/technical/Maintenance%20Flow%20Tech%20Memo%20Final.pdf

[72] Salwasser, H., L. Norris, and J. Nicholas. 2002. Expressing Oregon Environmental Benchmarks In Ecological Terms: Recommendations to the Oregon Progress Board. Progress Report 2 from the Science Working Group and Fish Benchmarks Summit Participants (November 19, 2002). Available from https://ir.library.oregonstate.edu/downloads/3197xr806

[73] Biron, P.M., Buffin-Bélanger, T., Larocque, M., et al. 2014. Freedom space for rivers: a sustainable management approach to enhance river resilience. Environmental management, 54(5), pp.1056-1073.

[74] Kondolf, G.M., 2012. The Espace de Liberte and restoration of fluvial process: when can the river restore itself and when must we intervene. Ch 18 in: River Conservation and Management, Wiley, pp.225-242.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
			mobility zone where there is a high risk of erosion or of avulsion (meander cutoff) over a 50-year period based on the extrapolation of migration rates calculated from historical data) + area of F_{high} (0–20 year flood return period) *See reference for method of calculation.*		long term through meander migration based on the extrapolation of migration rates calculated from historical data) + area of F_{med} (20–100 year flood return period) - L_{min} *See reference for method of calculation.*	
	% of stream and off-channel habitat length with lost floodplain connectivity (due to incision, roads, dikes, etc.)	e.g., mi channelized / mi stream length	> 50 %	10 – 50 %	< 10%	Table 10 in Nelitz et al. 2007[75](citing Smith 2005)[76], for streams <1% gradient
5.3 Promote and expand establishment of diverse riparian and wetland vegetation that contributes to complex channel and floodplain morphologies	% Site Shade Potential Realized	%	NA	NA	NA	CA: Figures 5.4-5.9 in NCRWQCB 2010[77] *(could use thresholds for overall shade for these benchmarks, i.e., >50% of site shade potential fulfilled might reflect Good status).*
	Total % Shade (Canopy Cover)	% Cover	General: <75% *(Not Functioning)* Coho: ≤70%	General: 75 – 95% *(At Risk or at At High Risk)* Coho: 71-80%	General: > 95% *(Properly Functioning)* Coho: >80%	General: Tripp and Bird 2004[78] Coho: Table 4-6 in NMFS 2014[79]
	Large Woody Debris Recruitment	Pieces Pieces / mile	Key Pieces*: <2 pieces** Streams < 20ft Wide***: <54 Streams 20-30 ft Wide: <37 Streams >30ft Wide: <34	Key Pieces: 2-3 pieces Streams < 20ft Wide: 54 - 84 Streams 20-30 ft Wide: 37 - 64 Streams >30ft Wide: 34 - 60	Key Pieces: >3 pieces Streams < 20ft Wide: >85 Streams 20-30 ft Wide: > 65 Streams >30ft Wide: >60	Table 4-6 in NMFS 2014 (for coho) *Key pieces of large woody debris are pieces with a minimum diameter of 60 cm (2 ft) and a minimum length of 100 m (33 ft) (Foster et al. 2001). **Pieces of wood are defined as all wood pieces that are greater than 12 inches in diameter at 25 feet from thelarge end.

[75] [75] Nelitz, M., K. Wieckowski and M. Porter. 2007. Refining habitat indicators for Strategy 2 of the Wild Salmon Policy: Identifying metrics and benchmarks. Final report prepared by ESSA Technologies Ltd. for Fisheries and Oceans Canada. 79 pp. Available at: https://www.psf.ca/sites/default/files/335986.pdf
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Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
						***The number of pieces of wood in streams with a wetted width of less than 20 feet, between 20 and 30 feet, or greater than 30 feet.

Table C - 6. Proposed core performance indicators (CPIs) and published suitability thresholds for WATERSHED INPUTS related objectives.

Sub-Objective	Core Performance Indicator	Units	Published Suitability Thresholds			References
			Poor	Fair	Good	
6.1 Improve instream ecological flow regimes year-round for the Klamath River mainstem and tributary streams	# cfs dedicated to stream *(distinguish between temporary and permanent)*	count	NA	NA	NA	No guidance on thresholds found.
	Monthly flows as % of modelled historical natural flows	%	NA	NA	NA	Simulated historical natural flows at Link River and Keno dams are available via the USBR (see Ch 5 Summary), and could be used to set benchmarks:
6.2 Reduce anthropogenic fine sediment inputs while maintaining natural and beneficial fine sediment inputs	% embeddedness	unitless	>30	25-30	<25	Table 4-6 in NMFS 2014[80] (for coho)
	% fines (<1 mm)	unitless	> 15 (wet) > 11.1 (dry)	12-15 (wet) 8.9-11.1 (dry)	< 12 (wet) < 8.9 (dry)	Table 4-6 in NMFS 2014 (for coho)
	Total suspended sediments	ppm	>80	25-80	< 25	Table 10 in Nelitz et al. 2007 (citing EIFAC and DFO 2000)[81], see also Stalberg et al. 2009[82]
	Miles 303d listed for sediment	%	N/A	>0.1 % of streams	0% of streams	Table 4 in Fesenmeyer et al. 2013[83] *(indicator at subwatershed scale)*
	Road density	mi / mi²	> 3	3 – 2.5	< 2.5	Table 4 in Fesenmeyer et al. 2013 *(indicator at subwatershed scale)*
	Roads in riparian zone (miles road <200 m of steam / miles of stream)	mi / mi		0.25 – 0.1	<0.1	Table 4 in Fesenmeyer et al. 2013 *(indicator at subwatershed scale)*
6.3 Reduce external nutrient and pollutant inputs that contribute to biostimulatory conditions	Tailwater return flows per season	# acre-feet	0-150	150-300	>300	Appendix A, Question 2 in SVRCD 2013[84] *(scored for a "tailwater neighbourhood", defined as "a geographic area or mini-basin; where several fields contribute to a single tailwater return stream".)*

[80] NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch)

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