Sub-	Turner of March and Street		Ex	posure	1				
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities		_		_	_	_	_	
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stress from capture, handling, and relocation.Egg relocation is impractical, likely leading to mortality.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation.Risk of mortality from stranding if fish cannot be captured and relocated successfully.Juveniles:Increased competition once relocated, reduced growth and fitness, and increased predation exposure.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

. HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations		•						
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-			Exj	posure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modifications							
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	En mi to sho bao pra tur
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Lin pra con lea
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	En con and Re con act En rec of

Resulting Effects of the Submechanism
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival and fitness of juveniles and adults.
May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications							-	-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	SeasonalEggs and alevins; Juveniles; AdultsStressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation the affects ofSelect piped bypass system designs over creation of artificial bypass over creation of artificial bypass extensive riparian impact.		Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.	
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).	e Channel r (Herrera 2007b).	
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine and Lacustrine	•	•	•	•				
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	hiles All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

Sub-			Fy	nosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>		<u>.</u>			-		-
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Cl	nannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	en/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-			Exj	posure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Operations	-	-	-	-	-	-	-	-
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Sub-			Ex	posure				
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Av pra con lea
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Ev tox end me Co qu

HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Minimization Measures	Resulting Effects of the Submechanism
void large sediment pulses during nstruction where practicable.	May cause injury or mortality.
void nutrient inputs where acticable. Avoid in-water curing of ncrete or discharge of concrete achate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
aluate effluent potential to introduce kic substances. Require or courage use of upstream treatment easures prior to discharge. bordinate enforcement of water ality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-	Torres of March 2019		Exj	posure		1			
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications	-	-	-	-	-	-	-	-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	

d). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
							<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Ecosystem Fragmentation								
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.

Sub-			E	xposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

inued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Table A-2. HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-	Income of Marshaning (Ex	posure	1	1			Desciling Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities							-	-
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-			Ex	posure				Γ
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modifications	•	•	-		•	-	
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	En mi to sho bao pro tur
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Liı pra coı lea
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	En con and Re con act En rec of

Resulting Effects of the Submechanism
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival and fitness of juveniles and adults.
May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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Sub-	Impact Mechanism/	Exj	posure						
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic & Geomorphic Modifications		-					-	
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent			patterns.	
	Altered substrate composition and stability	bility (beginn project vility (beginn project and bec more pr over tim	Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

. HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

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Sub- activity Type	Impact Mechanism/ Submechanism	Stressor	Ex	posure Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Off-C	hannel Screens						I	1	
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

ued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-			Exj	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.			
	Water Quality Modifications											
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.			
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.			
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.			

I). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-			Ex	posure			_					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.			
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.			
	Riparian Vegetation Modifications											
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.			
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults						
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles						
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults						
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults						

Sub-		Impact Mechanism/							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications					-			
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduits	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	<u>-</u>				•		<u>.</u>
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and anothing and invanile reacing babitat	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.
							spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.		

HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Table A-3. HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-	Trans (Markensler)	Expo		posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Ch	annel Screens								
	Construction and Maintenance Activities			_	_	-			
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Impost Mashanism/		Ex	posure	r	r			Domiting Efforts of the
Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
Operations								
Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

d). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-	ty Impact Mechanism/		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications							-	
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.	
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation							_	
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

		D	DOSURO					
Impact Mechanis Submechanism	sm/ 1 Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
hannel Screens								
Construction and Maintenance Activit	ies							
Equipment operation a materials placement	and Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dewatering and handl	ing Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Operations								
Visual, physical, and related disturbance	noise Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-		Impact Mechanism/				_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.

HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

ub-			Ex	posure					
ctivity Sype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
	Hydraulic & Geomorphic Modifications							-	
	Altered flow conditions Altered channel geometry	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round Year-round (with stressor exposure	Permanent Permanent	Continuous Seasonal	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u> : Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
			occurring during high-flow events, fall through spring)				<u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	

. HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.		
							<u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Ecosystem Fragmentation								
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.

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Sub- activity Type	Impact Mechanism/ Submechanism	Exposure							
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Table A-3 (continued).

Table A-4. HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-	Impact Mechanism/ Submechanism	Exposure					_		Develting Effects of the
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub- activity Type	Impact Mechanism/ Submechanism		Ex	posure		1			
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential redd scour and/orsedimentation, resulting in decreasedincubation success.Juveniles:Altered habitat suitability,increased stress, increased competition,decreased growth and fitness.Adults:Delayed migration, increased stress,decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.
Sub-			Ex	xposure				Desulting Effects of the	
activity Fype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations				-				
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-			Ex	posure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modifications	-	-	-	-	-	-	
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	En mi to sha pra tur
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Lin pra co: lea
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	En cor and Re cor act En rec of

Resulting Effects of the Submechanism
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival and fitness of juveniles and adults.
May affect survival, growth, and fitness at all exposed life-history stages.

Table A-4 (continued).HPA HCF

HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins;Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages.Select piped bypa over creation of a channels where p avoid/minimize d vegetation. Desig and outfalls for m impact.AdultsHowever, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects ofSelect piped bypa over creation of a channels where p avoid/minimize d vegetation. Desig and outfalls for m impact.	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications	-	-	-	-	-	-	-	-
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry availability and	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	_	negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.		control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous				
l	Marine			·	·				
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitabilityYear-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)Perma Perma variable effects depending on site- specific current dynamics and project configuration)Perma Perma Perma variable effects depending on site- specific current dynamics and project configuration)Perma Perma Perma (beginning with project installation and becoming more pronounced over time	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.		
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

d). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

nued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

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Impact Mechanism/ Submechanism	Stressor	Ex	posure Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
hannel Screens								
Construction and Maintenance Activities								
Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Operations								
Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Exj	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.			
	Water Quality Modifications											
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.			
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.			
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.			

I). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Import Machaniam/			Exj	posure								
у	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor					
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.					
-	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.					
	Riparian Vegetation Modifications	arian Vegetation difications										
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of					
-	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).					
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles						
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults						
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults						

. HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Minimization Measures	Resulting Effects of the Submechanism
Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications		-	-	-	-		-	-
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Lous Eggs and alevins; Eggs and alevins: Changes in channel Carefully Juveniles; morphology, flow velocity, and substrate design a	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)PermanentSeasonalAdultsComposition can under substitute e and stability, leading to decrease success and alevin survival. Juveniles: Altered channel geon velocity, and substrate compositi in decreased rearing habitat suita changes in food web complexity	d stability, leading to decreased incubation ccess and alevin survival. <u>veniles</u> : Altered channel geometry, flow locity, and substrate composition can result decreased rearing habitat suitability, and anges in food web complexity. This may					
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

Table A-4	(continued)
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HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-		-	-	-	<u>.</u>	-	-
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with baroed implications for porcelation productivity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.
							downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

 Table A-5. HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	<u>Eggs and alevins, juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Impact Machanism/		Ex	posure	I	ï			Dosulting Efforts of the
Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
Operations								
Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
Water Quality Modifications						entrainment. Mortality from entrainment into intake system.		

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Riparian Vegetation Modifications									
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	and alevins; iles; s S S S S S S S S S S S S S		May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults				
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles				
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults				
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults				

Sub-			Ex	posure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic & Geomorphic Modifications		-			-			
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year round	Permanent	Continuous		tilose siluctures fauler than the screens.		
	Marine and Lacustrine	-	·						
	Altered wave energy	ergy Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability relocities stability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-C	hannel Screens								
	Construction and Maintenance Activities								

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

ty Impact Mechanism/ Submechanism			Ex	posure	r	r		
	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a
	Operations							
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Sel pas Wh clea des

ed). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Minimization Measures	Resulting Effects of the Submechanism
/a	n/a
elect screen designs that employ assive clearing where practicable. Where mechanical screens and debris learing systems are necessary, select esigns that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-			Ex	posure			_		
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
	Hydraulic & Geomorphic Modifications					·			
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect

Sub-			Ex	posure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Adults	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	pro des cha sub gro ext
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	

 Table A-5 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

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Minimization Measures

oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.

Resulting Effects of the Submechanism

spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	:	:	- <u>-</u>		•	<u>.</u>	<u>.</u>
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	and diversity. <u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-	Lune of Masherizm/		Ex	posure					Develting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

I). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-			Ez	xposure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

. HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-			Ex	posure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modifications							
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	En mi to sh ba pra pra tu
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Lin pra con lea
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	En cor and Re cor act En rec of

Resulting Effects of the Submechanism
May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival and fitness of juveniles and adults.
May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
	Riparian Vegetation Modifications									
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Eggs and alevins;Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages.Select piped bypass system designsMaAdultseffects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects ofSelect piped bypass system designs over creation of artificial bypass avoid/minimize disturbance of riparian impact.MaMa over creation of artificial bypass vegetation. Design bypass systems and outfalls for minimal riparian impact.Ma	essors related to extensive modification of arian vegetation can impose a number of ects across all life-history stages. wever, riparian modification resulting from a screen development is expected to be ited in most cases. Development of bypass innels would be expected to cause more ensive riparian modification, however bass system development is considered to ensive riparian modification, however	
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults				
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles				
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults				
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults				

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications			-		-	-	-	-
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine and Lacustrine			•					
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

ıb- tivity ype	Impact Mechanism/ Submechanism	Stressor	Ex _] When	posure Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
off-C	hannel Screens							1				
	Construction and Maintenance Activities											
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Operations											
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.			

Sub-			Exj	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

d). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-	In a st Mashanimu (Exposure						Desulting Effects of the	
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-Exposure Impact Mechanism/ activity Submechanism Frequency **Response to Stressor** Туре Stressor When Duration Life-history Form Hydraulic & Geomorphic Modifications Change in habitat structure and habitat Eggs and alevins: Changes in channel Altered flow conditions Year-round Permanent Continuous Eggs and alevins; suitability, reduced food web complexity, morphology, flow velocity, and substrate Juveniles; and reduced spawning and rearing habitat composition can alter substrate composition Adults availability and suitability and stability, leading to decreased incubation Altered channel geometry Year-round (with Permanent Seasonal success and alevin survival. stressor exposure occurring during <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result high-flow events, in decreased rearing habitat suitability, and fall through changes in food web complexity. This may spring) limit foraging opportunities and increase Year round Altered substrate Permanent Continuous competition for suitable habitats, leading to composition and stability decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to

 Table A-6 (continued).
 HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is

affected.

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	-	-		-			÷
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	and diversity. <u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-			Exj	oosure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-7. HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure					
activity Гуре	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations			·	·	·			
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure		-		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modifications		-	-	-			
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	En min to o sho bac pra pro tur
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Lir pra coi lea
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Em cor and Red cor act End rec of 1

HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Minimization Measures	Resulting Effects of the Submechanism
insure project design avoids and/or ninimizes habitat alterations leading o chronic bank instability. Avoid hort-term turbidity effects above ackground levels to greatest extent racticable. Adhere to established rotocols for managing sediment and irbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
imit nutrient inputs where racticable. Avoid in-water curing of oncrete or discharge of concrete eachate to surface waters.	May affect survival and fitness of juveniles and adults.
Employ appropriate BMPs during construction to avoid accidental spills nd/or minimize their extent. Require a spill control and containment plan for construction ctivities. Encourage improved management of ecreational uses to limit introductions f toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-7 (continued).
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HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
Sub-			Ex	posure					
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activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications								
	Riverine	_					-	-	-
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine	·	·	·	·			•	
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

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). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-			-
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-C	hannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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Table A-7	(continued).
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HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-	Import Machanism/		Exj	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Operations				-		-		_
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

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Table A-7	(continued).
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HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Av
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Av pra con lea
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Ev tox end me Co qua

Minimization Measures	Resulting Effects of the Submechanism
void large sediment pulses during nstruction where practicable.	May cause injury or mortality.
void nutrient inputs where acticable. Avoid in-water curing of ncrete or discharge of concrete achate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
aluate effluent potential to introduce kic substances. Require or courage use of upstream treatment easures prior to discharge. bordinate enforcement of water ality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-7	(continued).
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HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications							-	
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications				-	-			
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Addits	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
Altered substrat composition and	Altered substrate composition and stability		Year round	Permanent	Continuous				

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Sub			Fv	nasura					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		<u>.</u>	<u>.</u>	-	-		<u>.</u>	<u>.</u>
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

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Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-8. HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
Dewatering	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully. <u>Juveniles</u> :Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure. <u>Adults</u> :Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-	Impact Machanism/		Ex	posure		_		Deculting Effects of the	
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

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Table A-8	(continued).
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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-	Import Machanism/		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications	•	-	-	-	-	-	-	-
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-	Laure (Machaeline (Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications				-				
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous Juveniles; Adults				
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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Table A-8	(continued).
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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-	Lung of Mashanian (Exj	posure			_		Descriting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic & Geomorphic Modifications		-	-	-	-			-
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine and Lacustrine							·	
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

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Sub-	Impact Machanism/		Ex	posure	1	Ì			Desulting Effects of the
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Off-C	hannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-		Exposure							
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic & Geomorphic Modifications					-			
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Aduits	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

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Table A-8	(continued)
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HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	<u>.</u>	-	-	-	-	<u>.</u>	5	
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

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Sub-	Sub- ctivity Impact Mechanism/		Ex	posure	1			Desciling Effects of the	
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens			• •					
	Construction and Maintenance Activities			_	_				
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

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HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-	Impost Mashanism/		Ex	posure	T				Doculting Efforts of the
аспуну Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

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HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-			Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	<u>Alevins and juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

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Sub-	Turner (Marchanitary (Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of mathing the channel of the channels.	vegetation can impose a number of across all life-history stages. er, riparian modification resulting from een development is expected to be in most cases. Development of bypass s would be expected to cause more ve riparian modification, however system development is considered to cicial channel creation, the effects of	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications		-	-	-	-			-
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Lacustrine							1	
	Altered wave energy	Change in habitat structure and habitat Ye suitability; reduced food web complexity, structure habitat availability, and suitability occ and juv ne: for Ye Ye Ye Ye Suitability; reduced food web complexity, structure ne: for Ye Ye Ye Ye	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

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HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

		Exj	posure			-		
Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
hannel Screens								
Construction and Maintenance Activities								
Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Operations								
Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

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HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-	ty Impact Mechanism/		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

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HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-	Lucia A Markania (Ex	posure			_		
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications	-	-	-	-		-	-	-
	Altered flow conditions Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the spawning productivit	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.	
	Altered channel geometry	d channel geometry	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Aduns	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		

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b-			Ex	posure					
ivity pe	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		•		<u>-</u>		-	•	-
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-10. HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations							·	·
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

. HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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Sub-Exposure Impact Mechanism/ activity Submechanism **Response to Stressor** Stressor When Duration Life-history Form Туре Frequency Water Quality Modifications Eggs and larvae: Turbidity sufficient to cause Elevated suspended Increased substrate embeddedness, Dependent on Temporary to short-Intermittent to Eggs and larvae; Ens sediments decreased sensory ability, gill clogging, contributing term (dependent on interannual-decadal fine sediment embeddedness may lead to mii Juveniles; gill abrasion mechanism of contributing (dependent on decreased survival of eggs and larvae. to Adults impact mechanism of contributing sho Juveniles and adults: Responses vary bac impact) mechanism of depending on stressor magnitude. impact) pra Unavoidable extreme turbidity may cause physical injury and/or physiological effects pro (e.g., gill trauma, altered osmoregulation, turl blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u>: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. Altered pH levels Interference with osmoregulation, Dependent on Juveniles; Juveniles and adults: Physiological responses Lin Temporary to short-Intermittent to respiratory distress, physiological injury contributing term (depending on interannual-decadal to pH levels outside of optimal thresholds, pra Adults mechanism of contributing (dependent on causing mortality or injury leading to reduced con impact mechanism of contributing fitness. lea impact) mechanism of impact) Intermittent to All expose life-history stages: Construction Introduction of toxic Intoxication, physiological injury Dependent on Temporary to long-Eggs and larvae; Em substances contributing term (depending on interannual-decadal Juveniles; and operation may lead to introductions of con contributing (dependent on mechanism of toxic substances through accidental spills or and Adults impact mechanism of contributing other pathways. Impoundments may attract Rec increased recreational vessel activity, creating impact) mechanism of con impact) a pathway for chronic exposure to acti hydrocarbons and other contaminants. End Exposure to toxic substances may lead to reci direct mortality, or physiological injury of limiting to survival, growth, and fitness.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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Minimization Measures	Resulting Effects of the Submechanism
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
nit nutrient inputs where acticable. Avoid in-water curing of acrete or discharge of concrete chate to surface waters.	May affect survival and fitness of juveniles and adults.
nploy appropriate BMPs during nstruction to avoid accidental spills d/or minimize their extent. quire a spill control and ntainment plan for construction ivities. courage improved management of rreational uses to limit introductions toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

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Sub- activity Type	Impact Mechanism/ Submechanism		Ex	posure								
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic & Geomorphic Modifications											
	Riverine											
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.			
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal							
	Altered substrate composition and stability		Year round	Permanent	Continuous							
	Lacustrine											
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.			
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent							
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous							
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous							
	Ecosystem Fragmentation											
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.			

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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v	Impact Mechanism/	Exposure Resulting Effects of the									
	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism		
Ch	annel Screens										
	Construction and Maintenance Activities										
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
Dredging and	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Operations										
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.		

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-10 (continued).HPA H

HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

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Table A-10 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-	In a st Mashanian (Ex	posure	1				Develting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).		
A	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-			posure					Resulting Effects of the	
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications		-			-			
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles;	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Addits			
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.		

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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	<u>-</u>	<u>+</u>	- <u>+</u>	<u>+</u>	<u>.</u>	-	-
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	and diversity.All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-			Exj	oosure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. <u>Juveniles</u> : Increased competition once relocated, reduced growth and fitness, and increased predation exposure. <u>Adults</u> : Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	<u>Eggs and larvae, juveniles</u> : Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg sedimentation, resulting in smothering and decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
	I a	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-11 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ех	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations		•	·				•	•
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-11 (continued).

. HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-			Ex	posure				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Water Quality Modifications	•		•	•		-	
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	E m tc sh ba pr tu
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	L pr co le
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	E co an R co ao E re of

Resulting Effects of the Submechanism
May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
May affect survival and fitness of juveniles and adults.
May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications			-	-				-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Eggs and larvae; Iuveniles;Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).Eggs and larvae; luveniles;	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
							•	•	

Sub-			Ex	posure					
activity Гуре	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications				-	-		-	-
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Sub-	Impost Mashanism/		Ex	posure				
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Off-C	hannel Screens							
	Construction and Maintenance Activities							
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/s
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations		•					
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/
	Water Quality Modifications							
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/s
	Riparian Vegetation Modifications							
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a		
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a		
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a		
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a		
	Hydraulic & Geomorphic Modifications							
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/
	Altered channel geometry	n/a	n/a	n/a	n/a			
	Altered substrate composition and stability	n/a	n/a	n/a	n/a			

Minimization Measures	Resulting Effects of the Submechanism
L	n/a
l	n/a
l	n/a
I	n/a
l	n/a
l	n/a
l	n/a
l	n/a
L	n/a
l	n/a

Table A-11 (continued).	HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-			-		
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Ch	annel Screens			·	·				
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-	Lune of Machanism (Ex	posure					Desalting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg scour and/or sedimentation, resulting in decreased incubation success. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and alevin survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
]	Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Sub-	Turner (Markani and)		Ex	posure			_		
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and alevin survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations						·		
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Sub-			posure						
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications		-	-	-	-		-	
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	SeasonalEggs and larvae; Juveniles; AdultsStressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects ofSelect piped bypass system over creation of artificial avoid/minimize disturb vegetation. Design byp and outfalls for minimal impact.	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications		:	<u>.</u>	<u>.</u>	-	•	•	<u>.</u>
	Riverine		-						
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to		control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Lacustrine		-						
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.	
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

Sub-			Exj	oosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation		-	-	-	-	-	-	
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-C	nannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	posure			-		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Operations	÷	-	-	-	2	<u>.</u>		-
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	ve modification of pose a number of ry stages.Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.May affect behavior and May affect survival, grow fitness during juvenile re intermediate-term periodWay affect behavior and May affect survival, grow fitness during juvenile re ation, however nt is considered to on, the effects of Channel (Herrera 2007b).May affect behavior and May affect survival, grow fitness during juvenile re intermediate-term period	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications						-	-	
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous Eggs and larvae; Eggs and larvae: Changes in channel Juveniles; morphology, flow velocity, and substrate A dulta composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.		
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	- Aduits	and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	spawning productivity.
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. <u>Adults</u> : Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.		

	Impost Mashanism/		Ex	posure	<u></u>				Dogulting Effects of the
	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
I	Ecosystem Fragmentation	•	-		-	-	•	-	-
F	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Juveniles</u> : Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. <u>Adults</u> : Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. <u>All exposed life-history stages</u> : Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock with	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
N	Modified downstream	Decreased food web productivity, altered	Year-round	Permanent	Continuous	Juveniles;	broad implications for population productivity and diversity. <u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic	Design diversion structure and fish	May affect juvenile survival, growth, and fitness. May affect adult spawning
a	and organic material					Adults	downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	fitness and productivity.

Sub-	Import Machanism/		Ex	posure	1	1			Deculting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Ch	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	squency Life-history Form Response to Stressor Minimization Measures arannual to adal (during ject construction i maintenance) Eggs and annocotes; Transforming adults; Adults All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage. Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheres and USPWS in voltar work windows. Use double-contined bubble curtain to reduce sound pressure; or work windows. Use double-control pharmers and wooden piles. Adults erannual to adal (during adal (during adal(s; adal (during adal(s; Adalts All exposed life-history stages: Adalts Engs and annocotes: Transforming adalts; Adalts Limit area of disturbance to the greannal to adal (during construction. Adalts Limit area of disturbance to the grean ada to bacter mortality, or physiological injury limiting to survival, growth, and fitness. Limit area of disturbance	Effects of underwater noise on lampreys are unknown.		
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Transforming adults; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults; Adults	<u>All life-history stages</u> : Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	Effects of underwater noise on lampreys are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes:Mortality, injury, or stress from capture, handling, and relocation.Egg and ammocoetes relocation is impractical, likely leading to mortality.Adults and transforming adults:Mortality, injury, or stress from capture, handling, and relocation.Risk of mortality from stranding if fish cannot be captured and relocated successfully.Adults:Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of transforming adults and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-13. HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-			Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults	Eggs and ammocoetes, transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when transforming adults are present.	May cause direct mortality or injury at transforming adult life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential egg scour and/or sedimentation, resulting in decreased incubation success. <u>Transforming adults</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and ammocoetes life-history stages; may affect transforming adult growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential decreased egg incubation success and ammocoetes survival due to turbidity exposure and substrate disturbance. <u>Transforming adults</u> : Stress and behavioral modifications by rearing transforming adults exposed to sediment pulses, migration delay, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at transforming adult life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	n/a	n/a	Lamprey are not dependent on invertebrates for prey. Therefore this stressor will have no effect.
		Loss of habitat access (during construction and maintenance or coffer dam placement)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Potential decreased egg incubation success and amocoetes survival due to water loss and stranding. <u>Transforming adults</u> : Barrier to migration, loss of habitat accessibility, stranding, migration delay, increased predation risk. Stranding may lead to direct mortality. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Transforming adults; Adults	<u>Transforming adults and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.

HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey. Table A-13 (continued).

Table A-13 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

			Ex	posure	·	·			
ÿ	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Direct injury or mortality from dredging entrainment. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury of eggs and amocoetes. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations		l		1				
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Amocoetes; Transforming adults; Adults	Amocoetes: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). May affect survival, growth, and fitness. <u>Adults and transforming adults</u> : Increased stress and exertion, leading to decreased survival and, in the case of adults, spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect survival, growth, and fitness across amocoetes, transforming adult, and adult life history stages. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Amocoetes; Transforming adults; Adults	<u>All exposed life history stages</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following stranding in or discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause injury or mortality across amocoetes, transforming adult, and adult life history stages. Multiple stressors may lead to decreased survival and fitness across all exposed life history stages.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause burial may lead to decreased survival of eggs and amocoetes. <u>Transforming adults and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Eggs and amocoetes; Transforming adults; Adults	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	<u>All exposed life history stages</u> : Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	<u>Transforming adults and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of transforming adults and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Table A-13 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and amocoetes; Transforming adults; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased egg dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and amocoetes; Transforming adults; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Transforming adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults			

HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey. Table A-13 (continued).

-			Ex	posure					
vity e	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications		-	-	-	-			
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	adults; Adults	negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine and Lacustrine	·							
M Al Al Al co	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when Transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	Transforming adults	An exposed me instory stages. The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Transforming adults		Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	

Sub-	Impact Mechanism/		Exj	posure			
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
Off-Ch	nannel Screens						
	Construction and Maintenance Activities						
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a
	Operations						
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Transforming adults; Adults	

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Minimization Measures	Resulting Effects of the Submechanism
n/a	n/a
n/a	n/a
Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	

		Ex	posure				
Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
Entrainment and	Stress, exertion, mechanical injury,	During screen	Permanent	Continuous	Transforming		En
impingement	diversion to unsuitable habitats	operation			adults		par
							ent
							lik
							Sit
							tha
							ris
Water Quality Modifications							
Increased suspended solid	Is Increased substrate embeddedness,	Dependent on	Temporary to short-	Intermittent to	Eggs and	Eggs and amocoetes: Turbidity sufficient to	En
-	decreased sensory ability, gill clogging,	contributing	term (dependent on	interannual-decadal	amocoetes;	cause burial may lead to decreased survival of	mi
	gill abrasion	mechanism of	contributing	(dependent on	Transforming	eggs and amocoetes.	to
		impact	mechanism of	contributing	adults;	Transforming adults and adults: Responses	sh
			impact)	mechanism of	Adults	vary depending on stressor magnitude.	ba
				impact)		Unavoidable extreme turbidity may cause	pi pr
						and/or physiological effects	tm
						(e.g., gin trauma, ancrea osmoregulation, blood chemistry changes). Moderate to high	· · u
						turbidity may cause behavioral alteration (e.g.	
						avoidance responses) leading to increased	
						territoriality, increased predation exposure,	
						and altered migration behavior.	
						Adults: Reduction in suitable spawning	
						habitat (due to substrate embeddedness) and	
						reduced spawning success.	
Increased water	Thermal stress	Limited to	Long-term to	Seasonal	Eggs and	All exposed life history stages: Thermal	٩
temperatures		stranding events in	permanent		amocoetes;	stress, physiological injury or mortality from	riŗ
		bypass channels			Transforming	acute temperature exposure	ap
					adults;		th
					Adults		
Altered dissolved oxygen	Decreased DO levels	Limited to	Temporary to short-	Intermittent to	Eggs and	All exposed life history stages: Physiological	A
levels		stranding events in	term (e.g.,	permanent	amocoetes;	injury or mortality from acute decreased DO	co
		bypass channels	contaminant spill or	(dependent on	Transforming	exposure	
			discharge) to long-	contributing	adults;		
			term (e.g., from	mechanism of	Adults		
			eutrophication effects	impact)			
			impoundment)				
			dependent on				
			contributing				
			mechanism of impact				
Altered pH levels	Interference with osmoregulation,	Dependent on	Temporary to short-	Intermittent to	Transforming	Transforming adults and adults: Physiological	Li
-	respiratory distress, physiological injury.	contributing	term (depending on	interannual-decadal	adults;	responses to pH levels outside of optimal	pr
		mechanism of	contributing	(dependent on	Adults	thresholds, causing mortality or injury leading	co
		impact	mechanism of	contributing		to reduced fitness.	lea
			impact)	mechanism of			
		1	1	(impact)	1		1

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Minimization Measures	Resulting Effects of the Submechanism
nploy conservative design rameters as necessary to avoid trainment or impingement of the nallest, weakest swimming species rely to be exposed to the screen. the bypass system outfalls at locations at deter predator loitering and reduce k of predation.	
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating Eggs and amocoetes. May affect transforming adult growth and fitness and adult productivity and spawning success.
yoid/minimize disturbance of parian vegetation. Maintain system- propriate riparian buffer widths to e greatest extent possible.	May cause injury or mortality.
void large sediment pulses during nstruction where practicable.	May cause injury or mortality.
mit nutrient inputs where acticable. Avoid in-water curing of ncrete or discharge of concrete achate to surface waters.	May affect survival and fitness of transforming adults and adults.

Table A-13 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-	Trans (Markanian (Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities. Maintain mechanical components to prevent leakage and/or spills.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and amocoetes; Transforming adults; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased egg dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and amocoetes; Transforming adults; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Transforming adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults			

HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey. Table A-13 (continued).

Sub-											
activity Type	Impact Mechanism/ Submechanism	Stressor	When Duration		Frequency Life-history Form		Response to Stressor				
	Hydraulic & Geomorphic Modifications										
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming		Ca de im			
	Altered channel geometry availability and suitability		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	adults; Adults		pr de ch su gr ex			
	Altered substrate composition and stability		Year round	Permanent	Continuous						
	Ecosystem Fragmentation										
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Transforming adults; Adults		Re eff an rai Ind ma HI			
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Transforming adults; Adults		De sc: we im ma do do			

Minimization Measures	Resulting Effects of the Submechanism
arefully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on annel geometry, flow velocity, bstrate composition, and oundwater exchange to the greatest tent practicable.	
equire assessment of the hydraulic fects of the project before permitting d require consideration of the full nge of fish passage needs in design. corporate monitoring and aintenance requirements into the PA.	
esign diversion structure and fish reen to pass organic material and body debris. Return entrained or pinged woody debris and organic aterial to the stream channel wnstream of the screen and version structure.	

Sub-		E E				7			Damilting Effects of the
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-14. HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and larval survival due toturbidity exposure and substrate disturbance.Juveniles:Stress and behavioralmodifications by rearing juveniles exposed tosediment pulses, migration delay, reducedforaging opportunities, and increasedpredation risk.Adults:Stress and behavioral modificationsby adults exposed to sediment pulses.Potential migration delay, leading to reducedspawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	<u>Juveniles</u> : Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-14 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.
Sub-			Ex	posure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Potential decreased eggincubation success and larval survival due towater loss and stranding.Juveniles:Barrier to migration, loss of habitataccessibility, stranding, migration delay,reduced foraging opportunities, increasedpredation risk.Stranding may lead to directmortality.Adults:Potential migration barrier and delay,leading to reduced spawning productivity,foraging success.Stranding may lead to directmortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-14 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications		-	-		-	-	-	-
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon. Table A-14 (continued).

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Sub-			Fx	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry Altered substrate composition and stability	variability and suitability Year- stress occur high-t fall th spring Vear	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability	-	Year round	Permanent	Continuous		those structures rather than the screens.		
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.	
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon. Table A-14 (continued).

Table A-14 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-			Exj	posure			-		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation	-	-	:	:	<u>.</u>	<u>.</u>	<u>.</u>	
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-C	nannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-14 (continued).HPA

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Operations			-	-	-	-		
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles;	<u>All exposed life history stages</u> : Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles;	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-14 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

			Ex	posure					Damiking Effects of the
7	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		•	•	-	•	÷	÷	-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Hydraulic & Geomorphic Modifications								
	Modifications Altered flow conditions 0	Change in habitat structure and habitat n/a suitability, reduced food web complexity, and reduced spawning and rearing habitat	n/a	n/a	n/a	n/a	Riverine systems supporting sturgeon spawning and larval rearing are expected to be insensitive to the potential hydraulic and	n/a	n/a
	Altered channel geometry	availability and suitability	n/a	n/a	n/a	1	geomorphic effects of off-channel fish		
Altered channel geometry Altered substrate composition and stability		n/a	n/a	n/a		screens.			

Table A-14	(continued).	HPA
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HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-			Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Ecosystem Fragmentation								
	Passage barriers	 Complete or partial barriers to downstream dispersal imposing the following stressors: Inability to access otherwise suitable rearing habitats Increased predation exposure 	Seasonal to year- round (depending on the nature of the barrier condition)	Permanent	Continuous	Larvae; Juveniles;	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: <u>Larvae and juveniles</u> : Impaired dispersal to favorable downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, larval, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Sub-			Exj	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Mortality, injury, or stressfrom capture, handling, and relocation.Eggrelocation is impractical, likely leading tomortality.Adults and juveniles:Mortality, injury, orstress from capture, handling, and relocation.Risk of mortality from stranding if fish cannotbe captured and relocated successfully.Juveniles:Increased competition oncerelocated, reduced growth and fitness, andincreased predation exposure.Adults:Delayed migration resulting indecreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential dispersal to unfavorable rearing areas. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Stress, injury, decreased feeding success. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. <u>Adults</u> : Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at larval and juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	This effect is not expected to be significant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or exclusion removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Adults	<u>Adults</u> : Decreased access to potential spawning habitat.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect adult spawning fitness and productivity.

Table A-15 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance, decreased foraging success. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-15 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-			Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modifications	÷	•	-	-	-	-	÷	÷
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure		_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Riparian Vegetation Modifications		-			-			
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

			Ex	posure			
7	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
	Hydraulic & Geomorphic Modifications						
	Riverine						
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and larvae; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.
	Marine and Lacustrine						
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous		
	Ecosystem Fragmentation						
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	Larvae: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival

Minimization Measures	Resulting Effects of the Submechanism
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Sub-	Immed Machanism (Impact Mechanism/			γ				Descriting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
Off-C	hannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	n/a	n/a	n/a	n/a	Off-channel screen systems are not expected to be in operation during periods when	n/a	n/a
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	n/a	n/a	n/a	n/a	eulachon and smelt spawning are present	n/a	n/a

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications		-	-	-				
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. <u>Adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	Decreased DO levels	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Adults	<u>Adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

			Ex	posure					
r ity e	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications					-			-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
-	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
-	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
-	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Hydraulic & Geomorphic Modifications							·	
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	n/a	n/a	n/a	n/a	Riverine systems supporting eulachon and smelt spawning are expected to be insensitive to the potential hydraulic and geomorphic	n/a	n/a
	Altered channel geometry	availability and suitability	n/a	n/a	n/a	_	effects of off-channel fish screens.		
	Altered substrate composition and stability		n/a	n/a	n/a	_			
	Ecosystem Fragmentation								
	Passage barriers	 Complete or partial barriers to downstream dispersal imposing the following stressors: Inability to access otherwise suitable rearing habitats Increased predation exposure 	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Exp	oosure	_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a



Sub-			Ex	posure		1			
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Ch	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project- specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Eggs and Larvae; Juveniles; Adults	Eggs and larvae: Injury or mortality from mechanical injury. Juveniles and adults: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Injury or mortality probable during dewatering, capture and relocation impractical. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-16. HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages</u> : See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

Table A-16 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Exposure Impact Mechanism/ Submechanism **Response to Stressor** Stressor When Duration Life-history Form Frequency **Operations** Visual, physical, and noise Increased stress, startle responses During screen Permanent Intermittent to Juveniles: Juveniles: Increased stress and exertion, related disturbance operation continuous avoidance of otherwise suitable habitats Adults (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness. Larvae and juveniles: Increased stress and Entrainment and Stress, exertion, mechanical injury from During screen Permanent Continuous Larvae exertion when avoiding impingement impingement; stress and disorientation from operation Juveniles entrainment through bypass systems; entrainment/impingement, leading to entrainment losses from ineffective decreased survival, growth, and fitness. Stress screening. from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system. Water Quality Modifications Elevated suspended Increased substrate embeddedness, Dependent on Temporary to short-Intermittent to Eggs and larvae; Eggs and larvae: Turbidity sufficient to cause decreased sensory ability, gill clogging, contributing term (dependent on interannual-decadal fine sediment embeddedness may lead to sediments Juveniles; gill abrasion mechanism of contributing (dependent on decreased survival of eggs and larvae. Adults mechanism of contributing impact Juveniles and adults: Responses vary impact) mechanism of depending on stressor magnitude. impact) Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and

Temporary to short-

term (depending on

contributing

impact)

mechanism of

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

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Interference with osmoregulation,

respiratory distress, physiological injury

Dependent on

contributing

impact

mechanism of

Altered pH levels

Sub-

Туре

activity

Juveniles;

Adults

Intermittent to

(dependent on

contributing mechanism of

impact)

interannual-decadal

reduced spawning success.

fitness.

Juveniles and adults: Physiological responses

causing mortality or injury leading to reduced

to pH levels outside of optimal thresholds,

Minimization Measures	Resulting Effects of the Submechanism
Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

May affect survival and fitness of Limit nutrient inputs where juveniles and adults. practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

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Table A-16 (continued).

HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-	ty Impact Mechanism/		Exj	posure			_	
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
	Hydraulic & Geomorphic Modifications	-						
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	C de in pr de se pa
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	ar-round (with Permanent Intermittent riable effects pending on site- ecific current namics and oject nfiguration)			diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	pa
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous	0		
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous			
	Ecosystem Fragmentation	-						
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	Larvae: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Ca by de an ar
Off-Ch	nannel Screens							
	Construction and Maintenance Activities							
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/
	Operations	l	<u> </u>	I			l	
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/

HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance. Table A-16 (continued).

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift tterns, and wave energy and current tterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
refully site screen intakes and pass systems to avoid migration lay effects. Ensure that approach d bypass attraction velocity criteria e suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
L	n/a
ı	n/a
1	n/a
I	n/a

Table A-16 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-	ty Impact Mechanism/		Exp	posure					Descriting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a			

HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance. Table A-16 (continued).

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications		-						
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry	n/a	n/a	n/a	n/a				
	Altered substrate composition and stability	n/a	n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Rupture of egg membrane. Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project- specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Eggs and Larvae; Juveniles; Adults	Eggs and larvae: Injury or mortality from mechanical injury. <u>Juveniles and adults</u> : Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

	Import Mash		Ex	posure	1	1			Doculting Difference of the
у	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae:Injury or mortality probable during dewatering, capture and relocation impractical.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. <u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages</u> : See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. <u>Adults</u> : Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.

	Terrer (Markenstern)		Ex	posure		.		l
y	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Av bac
	Operations							
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Wh clea des me
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Em par ent sm like Sit tha risl
	Water Quality Modifications							
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensi min to c shc bac pra pro turl

Minimization Measures	Resulting Effects of the Submechanism
void turbidity effects above ckground levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
here mechanical screens and debris earing systems are necessary, select signs that produce minimal echanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
nploy conservative design rameters as necessary to avoid trainment or impingement of the sallest, weakest swimming species ely to be exposed to the screen. e bypass system outfalls at locations at deter predator loitering and reduce k of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Sub-	Impact Machanism/		Ex	posure	1	1			Deculting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Sub-			Ext	osure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic & Geomorphic Modifications	-	-	-	-	-	-	-	-			
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.			
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.				
	Altered substrate composition and stability Altered groundwater-		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous							
	Altered groundwater- surface water exchange	red groundwater- ace water exchange	Year-round	Permanent	Continuous							
	Ecosystem Fragmentation											
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	Larvae: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.			
Off-Cl	annel Screens											
	Construction and Maintenance Activities											
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Operations											
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			

Sub-	7 Impact Mechanism/		Fx	nosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications		-	-	-	-		-	-
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Riparian Vegetation Modifications	• •							
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-18. HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-			Ex	posure		_				
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism	
In-Channel Screens										
	Construction and Maintenance Activities									
	requipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project- specific noise intensity and receptor exposure. May cause direct mortality or injury.	
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles; Adults	Larvae: Injury or mortality from mechanical injury. Juveniles and adults: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.	
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.	
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.	
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.	
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Injury or mortality probable during dewatering, capture and relocation impractical. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.	

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles;	Larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

Sub-			Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Operations		-	-	-			-	-
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Table A-18 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-	Impact Mechanism/ Submechanism		Ex	posure					
activity Type		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae; Juveniles	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles	bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles			
	Altered groundwater– surface water exchange	Reduced available suitable rearing habitat	Year-round	Permanent	Continuous	Larvae;			
Sub-			Exj	posure					
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activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor		
	Hydraulic & Geomorphic Modifications						-		
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Car desi imp proj desi sed patt	
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patt	
	Altered substrate composition and stability	rate and stability		Permanent	Continuous				
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Altered dispersal patterns	Altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	Larvae: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Car byp effe Ens attr for	
Off_C	hannel Screens								

Table A-18 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Construction and Maintenance Activities	Construction and Maintenance Activities										
Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a				
Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a				
Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a				
Operations											
Visual, physical, and noise related disturbance	n/a	n/	n/a	n/a	n/a	n/a	n/a				
Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a				

Minimization Measures	Resulting Effects of the Submechanism
refully evaluate project siting and sign and consider the magnitude of pact mechanisms produced by the oject. Encourage selection of project signs that minimize effects on liment supply, longshore drift terns, and wave energy and current terns.	Effects of screens are expected to be insignificant relative to the effects of intakes or diversions they are associated with.
refully site screen intakes and pass systems to avoid potential ects on larval dispersal patterns. sure that approach and bypass raction velocity criteria are suitable the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
	n/a
L	n/a
	n/a
	n/a
	n/a

Sub-			Fyna	sure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications				-	-		-	-
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Riparian Vegetation Modifications		·						
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	posure			_		
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Ch	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project- specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles	Larvae: Injury or mortality from mechanical injury. Juveniles and adults: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles	<u>Juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Injury or mortality probable during dewatering, capture and relocation impractical. <u>Adults and juveniles</u> : Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-19. HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles;	Larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>Juveniles</u> : Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. <u>All life-history stages</u> : See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Table A-19	(continued)
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HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-	Impact Machanism/		Ex	posure	1	1			Deculting Effects of the
аспуцу Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Operations	-		-	-		-		
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Sub-	ty Impact Mechanism/		Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae; Juveniles	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub	<u> </u>		Fy	2050180					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications	•			:	-	<u>.</u>		
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	Effects of screens are expected to be insignificant relative to the effects of intakes or diversions they are associated with.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.	
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous	0			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Altered dispersal patterns	Altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	Larvae: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid potential effects on larval dispersal patterns. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Cl	nannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-	Impost Mashanism/		Exj	posure					Doculting Efforts of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modifications						-	-	-
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	 <u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase foraging efficiency due to decreased ability to sense predators and prey Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness. 	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project- specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles; Adults	Larvae: Injury or mortality from mechanical injury. Juveniles and adults: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u> : Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae:Injury or mortality probable during dewatering, capture and relocation impractical.Adults and juveniles:Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life- history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Potential decreased larval survival due to water loss and stranding. Barrier to dispersal, loss of habitat accessibility, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles	<u>Juveniles</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles	These effects are expected to be insignificant at the scale of construction related activities expected.	Avoid turbidity effects above background levels.	These effects are expected to be insignificant at the scale of construction related activities expected.
	Operations			-					
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

b-			Ex	posure					
ivity pe	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. <u>Adults</u> : Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success. Juveniles and adults: Physiological responses	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Sub-	ub- 		Ex	posure					Doculting Effects of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications		<u>.</u>	-	•	•	-		
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

Sub-			Exp	osure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications				-	-			
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
_	Altered current velocities	locities Year-round (with variable effects depending on site-specific current dynamics and project configuration) Permanent Intermittent Intermittent associated with, the effects are ascribed those structures rather than the screens. tability Year-round (beginning with project installation and becoming more pronounced over time Permanent Continuous	diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.					
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous	0			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u> : Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Ch	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Exj	posure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Water Quality Modifications	•	-	-		-	-				
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Riparian Vegetation Modifications										
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a					
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a					
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a					
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a					
	Hydraulic & Geomorphic Modifications										
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Altered channel geometry		n/a	n/a	n/a	-					
	Altered substrate composition and stability		n/a	n/a	n/a						
	Ecosystem Fragmentation										
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		

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Sub- activity	Impact Mechanism/		Ex	posure			4		Resulting Effects of the
Туре	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Ch	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Veliger larvae; Juveniles, Adults	All life history stages: Visual disturbance is not expected to have significant effects. Physical disturbance may lead to mechanical injury or mortality.	Avoid project siting in oyster habitat.	May cause direct injury or mortality.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	Veliger larvae, juveniles: Removal and relocation may be impractical. Stranding and exposure may lead to mortality. Adults: Temporary behavioral effects may occur as a result of relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows.	May cause juvenile and larval mortality. May alter adult behavior, with insignificant effects on fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae	<u>Veliger larvae</u> : Injury or mortality may occur as a result of pump entrainment, or impingement on intake screens.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval mortality.	May cause larval injury or mortality.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae	<u>Veliger larvae</u> : May affect dispersal and retention in areas favorable for rearing.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life- history stages.

Table A-21. HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

T	a at Maaka		Exj	posure	,	,	
Imp: St	act Mechanism/ ubmechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All exposed life history stages</u> : See response to related stressors under Water Quality Modification.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	This stressor is not expected to have any significant effect on this species.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	n/a
Dredgin	ng and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>All exposed life history stages</u> : May affect habitat suitability for this species, leading to effects on survival, growth and fitness.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Veliger larvae; Juveniles; Adults	These effects are expected to be insignificant at the scale of construction related activities expected.
Operati	ions						
Visual, j related c	physical, and noise disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Veliger larvae; Juveniles; Adults	All life history stages: No significant effects are expected from visual and physical disturbance related to operations. The effects of anthropogenic noise on this species is a data gap.
Entrainr impinge	ment and ement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Veliger Larvae	<u>Veliger larvae</u> : Injury and or mortality from entrainment into intake systems or impingement on screens.
Water (Modific	Quality cations						
Elevated	d suspended nts	Smothering, decreased feeding effectiveness, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	Veliger larvae:Turbidity sufficient to impact feeding effectiveness may lead to decreased survival of larvae. May affect larval settlement.Juveniles and adults:Responses vary depending on stressor magnitude.Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may affect feeding effectiveness.

. HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Minimization Measures	Resulting Effects of the Submechanism
here to system-specific in-water ork windows.	See effects for related stressors under Water Quality Modifications.
L	No significant effects expected.
L	n/a
roid project siting in sensitive bitats	May affect survival, growth and fitness.
oid turbidity effects above ckground levels.	These effects are expected to be insignificant at the scale of construction related activities expected.
oid project siting in oyster habitat.	Expected effects are insignificant or unknown.
nploy conservative design rameters as necessary to avoid rainment or impingement of the allest, weakest swimming species ely to be exposed to the screen.	May cause larval injury or mortality.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ckground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect larval survival of incubating larvae. May affect juvenile and adult growth and fitness.

Sub-			Ex	posure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All exposed life history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause mortality or affect survival and fitness of all exposed life history stages.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	The effects of this stressor at expected magnitudes are expected to be insignificant.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-			Ex	oosure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Hydraulic & Geomorphic Modifications			-		-						
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.			
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous	0						
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous							
	Ecosystem Fragmentation	tem Fragmentation										
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Veliger larvae	<u>Veliger larvae</u> : Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.			
Off-Cl	nannel Screens											
	Construction and Maintenance Activities											
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Operations											
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			

Table A-21 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Table A-21 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-	Impact Mechanism/		Ex	posure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism		
	Water Quality Modifications	-	-	-	•			-	-		
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Introduction of toxic substances (PAHs, metals, organic pollutante)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Riparian Vegetation Modifications										
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a		
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a					
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a					
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a					
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a					
	Hydraulic & Geomorphic Modifications										
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Altered channel geometry		n/a	n/a	n/a						
	Altered substrate composition and stability		n/a	n/a	n/a						
	Ecosystem Fragmentation										
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		

	1					1	1	1	
Sub- activity Type	Impact Mechanism/ Submechanism	Stressor	Ex	posure Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Ch	annel Screens		() Hell	Durunon	Trequency	Life instory round	Ĩ		
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on this species is a data gap.	Effect of increased ambient noise level on Northern abalone is a data gap.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles, Adults	All life history stages: Visual disturbance is not expected to have significant effects. Physical disturbance may lead to mechanical injury or mortality.	Avoid project siting in abalone habitat.	May cause direct injury or mortality.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Northern abalone is a data gap.	Effect of increased ambient noise level on Northern abalone is a data gap.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All life-history stages</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae, juveniles: Removal and relocation may be impractical. Stranding and exposure may lead to mortality. Adults: Temporary behavioral effects may occur as a result of relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows.	May cause juvenile and larval mortality. May alter adult behavior, with insignificant effects on fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Larvae: Injury or mortality may occur as a result of pump entrainment, or impingement on intake screens.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval mortality.	May cause larval injury or mortality.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Larvae: May affect dispersal and retention in areas favorable for rearing.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life- history stages.

Table A-22. HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

	Import Mashanians (Ex	posure	1	1		
у	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All exposed life history stages</u> : See response to related stressors under Water Quality Modification.	,
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	This stressor is not expected to have any significant effect on this species.	
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	n/a	
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	<u>All exposed life history stages</u> : May affect habitat suitability for this species, leading to effects on survival, growth and fitness.	ł
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Larvae; Juveniles; Adults	These effects are expected to be insignificant at the scale of construction related activities expected.	l
	Operations							
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Larvae; Juveniles; Adults	<u>All life history stages</u> : No significant effects are expected from visual and physical disturbance related to operations. The effects of anthropogenic noise on this species is a data gap.	
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae	<u>Larvae</u> : Injury and or mortality from entrainment into intake systems or impingement on screens.	
Water Quality Modifications								
	Elevated suspended sediments	Smothering, decreased feeding effectiveness, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to impact feeding effectiveness may lead to decreased survival of larvae. May affect larval settlement. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may affect feeding effectiveness	E n tr s b F F t

HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Minimization Measures	Resulting Effects of the Submechanism
here to system-specific in-water rk windows.	See effects for related stressors under Water Quality Modifications.
	No significant effects expected.
	n/a
oid project siting in sensitive bitats	May affect survival, growth and fitness.
oid turbidity effects above ekground levels.	These effects are expected to be insignificant at the scale of construction related activities expected.
oid project siting in abalone habitat.	Expected effects are insignificant or unknown.
nploy conservative design rameters as necessary to avoid rainment or impingement of the allest, weakest swimming species ely to be exposed to the screen.	May cause larval injury or mortality.
sure project design avoids and/or nimizes habitat alterations leading chronic bank instability. Avoid ort-term turbidity effects above ekground levels to greatest extent acticable. Adhere to established otocols for managing sediment and bidity.	May affect larval survival of incubating larvae. May affect juvenile and adult growth and fitness.

Sub-			Ez	xposure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All exposed life history stages</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause mortality or affect survival and fitness of all exposed life history stages.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Northern abalone are expected to be relatively insensitive to riparian vegetation modification. Further, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	The effects of this stressor at expected magnitudes are expected to be insignificant.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults	Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Table A-22 (continued).

Sub-		Exposure							
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications	•		<u>.</u>	<u>.</u>		-	•	<u>.</u>
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.	
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous	0			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	Larvae: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Cl	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-22 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Table A-22 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Water Quality Modifications			-					
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater- surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	nosure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
In-Cha	annel Screens				1				
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	n/a	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts	n/a	n/a
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	n/a	from fish screen construction. Impacts associated with project siting are associated with intake or diversion.	n/a	n/a
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	n/a		n/a	n/a
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
	Dewatering and handling	Removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a

Table A-23. HPA HCP Fish Screen Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>All exposed life history stages</u> : May affect habitat suitability for this species. Loss of obligate <i>Salicorna</i> spp. habitat would be expected to decrease survival, growth, and fitness.	Avoid project siting in sensitive habitats	May affect survival, growth and fitness.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	n/a	Habitats used by this species are restricted to a narrow band littorine and	n/a	n/a
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	n/a	riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from fish screen operation.	n/a	n/a
	Water Quality Modifications								
	Elevated suspended sediments	Smothering, decreased feeding effectiveness, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	n/a	n/a	n/a	n/a
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	n/a	n/a	n/a	n/a
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All exposed life history stages</u> : May cause injury, mortality or physiological effects on organisms exposed to pollutants at littorine fringe.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May cause injury or mortality. May affect survival, growth, and fitness at all exposed life-history stages.

Sub-			Ex	posure					
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications	-	-		-	-	-	-	-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	May affect habitat suitability for this species. Loss of obligate <i>Salicorna</i> spp. habitat would be expected to decrease survival, growth, and fitness. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	The effects of this stressor at expected magnitudes are expected to be insignificant.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater– surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			

Sub-			Exj	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic & Geomorphic Modifications	-	-	-	-	-	-	-	-
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities	Year-round (with variable effects depending on site- specific current dynamics and project configuration)	Permanent	Intermittent		diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	patterns.		
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous	0			
	Altered groundwater- surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>n/a</u>	n/a	n/a
Off-Cl	nannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Exj	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Water Quality Modifications	•	-	-	-		-	-	-
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Riparian Vegetation Modifications		L						
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	<u>n/a</u>	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater– surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Sub-			Ex	posure			_		
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	The effects of exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.

Table A-24. HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Table A-24 (continued).	HPA HCP Fish Screen Exposure and Response Matrix	for Giant Columbia River Limpet and Great Colun
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u Impost Mashaniam/			Ex	posure					
	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juvenile and adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May cause injury or mortality in all exposed life history stages.
D	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.
0) perations								
V re	'isual, physical, and noise elated disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>All exposed life history stages</u> : The effects of operational stressors on these species are a data gap.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	Effects of stressor exposure are unknown.
Ein	Intrainment and npingement	Stress, exertion, mechanical injury from impingement; stress from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages</u> : Injury or mortality from impingement on or entrainment through the screen. Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from passage through bypass systems.	Evaluate flow through velocities and screen mesh characteristics for potential effects on these species.	May cause injury or mortality. May affect survival, growth, and fitness.
W M	Vater Quality Iodifications								
Ese	levated suspended ediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.

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mbia River Spire Snail.

Table A-24 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

ıb-			Ex	posure					
tivity ype	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults			

Table A-24 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-	Impost Mashaniam/		Ex	posure				Descriting Difference of the	
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		those structures rather than the screens.		
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Off-C	hannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	The effects of exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u> : Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

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Table A-24 (continued).	HPA HCP Fish Screen Exposure and Response Matrix for	Giant Columbia River Limpet and Great Colum
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Sub-	Import Machanism/		Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u> : Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u> : Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u> : Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juvenile and adults</u> : Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May cause injury or mortality in all exposed life history stages.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages:</u> Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.

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mbia River Spire Snail.

Table A-24 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-			Ex	posure						
activity Type	Submechanism/	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism	
	Operations		-	-	-	-		-	-	
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	<u>Juveniles</u> : Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. <u>Adults</u> : Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.	
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	<u>Juveniles</u> : Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.	
	Water Quality Modifications									
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.	
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	Adults and juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality. May affect survival, growth, and fitness.	
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality. May affect survival, growth and fitness.	

Table A-24 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-			Ex	posure								
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect survival, growth and fitness.			
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.			
	Riparian Vegetation Modifications											
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.			
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).					
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults						
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults						
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults						
Table A-24 (continued).HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

)-			Ex]	posure					
ivity pe	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications					-			
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth and fitness at all exposed life history stages.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Passage barriers	 Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: Inability to access otherwise suitable rearing or spawning habitats Energy exertion or injury during attempts to navigate barrier condition Increased predation exposure Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population 	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness. The magnitude of this stressor resulting from fish screen operation is expected to be insignificant.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	Effects of stressor exposure are expected to be insignificant.

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Sub-	Impact Machanism/		Ex	posure	1	i	-		Doculting Efforts of the
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
In-Cha	annel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of construction noise on California floater and western ridged mussels at any life- history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia:Capture and removal of larvaeimpractical, high likelihood of larvalmortality.Adults and juveniles:Adults and juveniles:insensitive to handling stress, howeverinadvertent dispersal when relocated canaffect population productivity.Juvenilesensitivity to handling stress unknown.These species are also sensitive to effects onhost fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause larval mortality. May affect adult population productivity. Effects on host fish may also affect population productivity.

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: High likelihood of mortality from pump entrainment or impingement on screen filters. Juveniles and adults: Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	High likelihood of larval mortality from entrainment or impingement. The effects of juvenile and adult exposure to this stressor are expected to be low. Effects on host fish will indirectly affect population productivity.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival in all life stages.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect survival at juvenile and adult life-history stages.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. <u>Juvenile and adults</u> : Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival in all life stages.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochida; Juveniles; Adults	<u>Glochidia</u> : Direct injury or mortality from dredge entrainment. <u>Juveniles and adults</u> : Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual–decadal	Juveniles; Adults	<u>All life-history stages</u> : Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.

HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater. Table A-25 (continued).

Sub-			Ex	posure								
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism			
	Operations	-	<u>-</u>	<u>+</u>	<u>-</u>	<u>-</u>		-	-			
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	All exposed life history stages: The effects of operational stressors on these species are a data gap.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	Effects of stressor exposure are unknown.			
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	<u>Glochidia larvae</u> : Entrainment through screens is likely, leading to mortality. However this effect is attributable to the diversion and limitations of screen design, rather than the screen itself. <u>Juveniles and adults</u> : Being sessile benthic species, mussels are expected to be insensitivity to these stressors once attached to the substrate.	Evaluate flow through velocities and screen mesh characteristics for potential effects on these species.	No effect expected.			
	Water Quality Modifications											
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.			
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long- term (depending on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.			

Sub-			Ex	posure			_		
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults			

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HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater. Table A-25 (continued).

Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Hydraulic & Geomorphic Modifications			-	-	-			
	Altered flow conditions	Change in habitat structure and habitat	Year-round	Permanent	Continuous	Juveniles;	All exposed life history stages: The effects of	Carefully evaluate project siting and	Effects from in-channel screens are
	Altered channel geometry	suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Adults	in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are	design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest	expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered substrate composition and stability		Year round	Permanent	Continuous		associated with, the effects are ascribed to those structures rather than the screens.	extent practicable.	
Ecosystem Fragmentation									
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Off-C	nannel Screens								
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : The effect of construction noise on California floater and western ridged mussels at any life- history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u> : The effect of visual and physical disturbance on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short- term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u> : The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.

Sub-			Ex	posure	_	_			
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All exposed life-history stages</u> : See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	<u>Glochidia</u> : Capture and removal of larvae impractical, high likelihood of larval mortality. <u>Adults and juveniles</u> : Adults appear insensitive to handling stress, however inadvertent dispersal when relocated can affect population productivity. Juvenile sensitivity to handling stress unknown. These species are also sensitive to effects on host fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	<u>Glochidia:</u> High likelihood of mortality from pump entrainment or impingement on screen filters. <u>Juveniles and adults</u> : Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u> : Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect juvenile and adult growth and fitness at juvenile life-history stage.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All life-history stages</u> : See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	May affect growth and fitness at juvenile and adult life history stage.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. <u>Juvenile and adults</u> : Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	These species are non-migratory and insensitive to temporary barriers to passage.

HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater. Table A-25 (continued).

Sub-			Ex	posure					
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual-decadal	Juveniles; Adults	<u>Juveniles and adults</u> : See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochida; Juveniles; Adults	<u>Glochidia</u> : Direct injury or mortality from dredge entrainment. <u>Juveniles and adults</u> : Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short- term	Interannual-decadal	Juveniles; Adults	All life-history stages: Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations	_		_			-		
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	J <mark>uveniles</mark> ; Adults	<u>All exposed life history stages</u> : The effects of operational stressors on these species are a data gap.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	Effects of stressor exposure are unknown.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae:Entrainment through screens is likely, leading to mortality.However this effect is attributable to the diversion and limitations of screen design, rather than the screen itself.Juveniles and adults:Being sessile benthic species, mussels are expected to be insensitivity to these stressors once attached to the substrate.	Evaluate flow through velocities and screen mesh characteristics for potential effects on these species.	No effect expected.
	Water Quality Modifications		_		_	_	-	-	-
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short- term (dependent on contributing mechanism of impact)	Intermittent to interannual-decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. <u>Juveniles and adults</u> : Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.

Table A-25 (continued).	HPA HCP Fish Screen Ex	posure and Response Matrix for	Western Ridged Mussel and Cali	iforn
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Sub-			Ex	posure					
activity Type	Impact Mechanism/ Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	<u>Adults and juveniles</u> : Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system- appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality. May affect survival, growth, and fitness.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short- term (e.g., contaminant spill or discharge) to long- term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality. May affect survival, growth and fitness.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short- term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	<u>Juveniles and adults</u> : Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect survival, growth and fitness.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Juveniles; Adults	<u>All exposed life-history stages</u> : Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.



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Sub-	Luce of Machanisma (Ex	posure		·			
activity Type	Submechanism	Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Submechanism
	Riparian Vegetation Modifications	•	•	•	•		-	-	-
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults	which are addressed in the Channel Modifications white paper (Herrera 2007b).		
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater- surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Juveniles; Adults	<u>Juveniles and adults</u> : Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival, growth and fitness at all exposed life history stages.
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal		suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Passage barriers	Partial barriers to upstream or downstream passage of host fish.	Year-round	Permanent	Continuous	Glochidia larvae	Effects on host fish dispersal may affect the dispersal of larvae, affecting population productivity	Design fish screens to minimize passage related effects on host fish species.	May affect population productivity.

Table A-25 (continued).	HPA HCP Fish Screen H	Exposure and Response Ma	atrix for Western Ridged	Mussel and Californ
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Sub- activity Type	Impact Mechanism/ Submechanism	Exposure							
		Stressor	When	Duration	Frequency	Life-history Form	Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life-history stages</u> : Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness. The magnitude of this stressor resulting from fish screen operation is expected to be insignificant.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	Effects of stressor exposure are expected to be insignificant.

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