Attachment 9
Fish and Wildlife Discipline Report

CAPITOL LAKE – DESCHUTES ESTUARY

Long-Term Management Project Environmental Impact Statement

Fish and Wildlife Discipline Report

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Executive Summary

This Fish and Wildlife Discipline Report describes the potential impacts of the Capitol Lake – Deschutes Estuary Long-Term Management Project on fish and wildlife and their habitats. The Capitol Lake – Deschutes Estuary includes the 260-acre Capitol Lake Basin, located on the Washington State Capitol Campus, in Olympia, Washington. Long-term management strategies and actions are needed to address issues in the Capitol Lake – Deschutes Estuary project area. An Environmental Impact Statement (EIS) is being prepared to document the potential environmental impacts of various alternatives and determine how these alternatives meet the long-term management objectives identified for the watershed. This report was originally prepared to support the project's Draft EIS, and has been revised for the Final EIS. In general, revisions have been made to provide additional information, update and expand analyses and findings, refine measures to mitigate potentially significant impacts, and correct inadvertent errors. Notable substantive revisions in the Fish and Wildlife Discipline Report are as follows:

- The analysis was updated to reflect changes to the 5th Avenue Bridge design included in the Estuary and Hybrid Alternatives to avoid long-term closure of the 5th Avenue Bridge.
- The characterization of fish and wildlife impacts under the Hybrid Alternative was updated to reflect the change from a saltwater pool to a groundwater-fed, freshwater pool.
- Additional information was included on salmon use, historic and present, in the study area.
- Additional information was included on fish predation conditions and potential changes to predation under the alternatives.
- Additional information was included, and clarifications made related to: (1) the role of estuaries in supporting juvenile salmonids; and (2) salmonid predation, including an annotated bibliography of reviewed literature (see Appendix A).
- Additional information was included on freshwater mussel presence and potential impacts.
- Additional information was included, and clarifications made, related to bat use in the study area and potential impacts, including an annotated bibliography of reviewed literature (see Appendix B).

- The discussion of impacts and benefits on bird species groups was clarified.

The primary study area for fish and wildlife includes both the area where construction would occur under each alternative, as well as the remaining project area that supports species that could be affected by the project. The southern boundary is generally the base of Tumwater Falls, and the northern limit is the northern end of West Bay.

Potential impacts were determined by evaluating known occurrences of species, or species groups and indicator species in the study area, life history requirements, and the potential changes in habitat condition, extent, and availability under each alternative. For fish, the analysis considered changes in wetted area, bathymetry, salinity, tidal inundation, freshwater inputs, water quality, and sediment distribution. For wildlife, the analysis also considers changes in the availability of cover, food, predator-prey relationships, and breeding sites.

Construction impacts were analyzed based on the known relationships between construction elements (e.g., turbidity and construction noise) and the effects on fish and wildlife (e.g., avoidance, decreased foraging activity). The analysis considered construction timing, duration, methods, and best management practices (BMPs) and their relative implication for species and habitats under each alternative. Construction impacts were estimated based on the conceptual design for each alternative.

Operational impacts were analyzed by considering the projected outcome of each alternative and the changes to habitat and the corresponding effects to fish and wildlife species. Both long-term adverse impacts and beneficial effects associated with fish and wildlife are evaluated based on expected changes in ecological functions and processes within the study area.

The analysis examines the No Action Alternative, as well as three action Alternatives (Managed Lake, Estuary, and Hybrid).

The No Action Alternative would not result in construction impacts on fish and wildlife because the project would not be built. In the long term, the dam would remain in-place and minimal submerged aquatic vegetation removal would occur (consistent with current management practices). The lack of active lake management to remove sediment and aquatic vegetation could continue to affect habitat quality and habitat use by some fish or other aquatic species. In general, impacts on fish and aquatic habitat related to habitat changes from the lack of active lake management in Capitol Lake would be **less-than-significant** because the changes would occur incrementally and use of the basin by these species would still persist.

Under all action alternatives, potential construction impacts on fish and wildlife are associated primarily with initial dredging and creation of habitat areas, as well as the construction of new in-water/overwater structures. Impacts on fish and aquatic habitat would be **less-than-significant**, including impacts associated with fish entrainment and direct mortality, water quality, turbidity and sedimentation, and noise and vibration. Although individual fish or wildlife could be affected, these impacts are small and would not measurably affect their local populations. Impacts would be minimized through adherence to the agency-approved in-water work period and implementation of standard overwater and in-water construction BMPs in accordance with environmental regulatory permit requirements.

For the Managed Lake Alternative, construction of the dam overhaul repairs would have **less-than-significant impacts** on fish and wildlife based on the temporary nature of the repairs, and minimal in-water work required. For the Estuary Alternative, construction related to 5th Avenue Dam removal, Deschutes Parkway realignment and 5th Avenue Bridge demolition and construction, slope stabilization, and other activities, would involve longer duration disturbances and additional in-water activities. For the Hybrid Alternative, construction impacts and the duration of impacts would be the same as those described under the Estuary Alternative, but would also include installation of a barrier wall to create the new, smaller reflecting pool. With adherence to approved in-water work windows and standard construction BMPs, impacts on fish and wildlife from both alternatives would also be **less-than-significant.**

As with all action alternatives, the conversion of some areas of deepwater to wetland habitat areas would provide a **minor beneficial effect** for some species, such as raptors and songbirds.

Under the Managed Lake Alternative, habitat zones would change as sediment fills in the Middle and South basins, and as the result of the creation of habitat areas in the Middle Basin resulting in impacts that range from **minor beneficial effects** to **less-than-significant impacts**, depending on the species. General fish and wildlife distribution and use patterns would be similar to existing conditions. Potential adverse impacts of new overwater and in-water structures on habitat would be minor and **less-than-significant**.

Under the Estuary and Hybrid alternatives, impacts on fish and wildlife would range from **beneficial** to **less-than-significant** to **significant**, depending on the species. The estuary conditions created under the Estuary Alternative would result in **substantial beneficial effects** for salmon, other anadromous species, and marine fishes, including protected species within these groups. Under the Hybrid Alternative, the full range of estuarine functions would not develop over the entire North Basin area, resulting in somewhat reduced benefits. The physical footprint of the dam removal would have **moderate beneficial effects** on salmon and other fish species expected to use the estuary. Conversely, the brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, would not be suitable for freshwater fish species, resulting in mortality to these species and constituting a **significant impact** on this species group. For wildlife species, the change to an estuarine environment under the Estuary and Hybrid Alternatives is conservatively determined to be a **significant impact** on Yuma myotis and little brown bats at the Woodard Bay trestle colony because of the size of the colony, and their reported dependence on emergent insects in the freshwater environment of the Capitol Lake Basin. Conversely, there would be **substantial beneficial effects** for shorebirds and wading birds related to the conversion of freshwater to estuarine habitat because of an increase in suitable habitat and changes in the types of prey available for this species group.

All action alternatives could directly or indirectly affect tribal resources. As summarized above, this discipline report identifies significant adverse impacts on fish and wildlife species and aquatic habitat, as well as anticipated beneficial effects. These impacts/effects could impact or beneficially affect tribal resources, including fish, wildlife, and vegetation available for harvest and use by potentially affected tribes, including the Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation. Under the No Action Alternative, continuation of current, limited management practices would not benefit species of importance to the tribes, specifically salmon and shellfish. The impacts on salmon related to habitat changes from continued deposition of sediment in Capitol Lake would likely not measurably affect fish available for harvest. Under the Managed Lake Alternative, maintaining a freshwater lake system would not substantially benefit species of importance to the tribes. Impacts on salmon related to habitat changes from continued deposition of sediment in Capitol Lake would likely not measurably affect fish available for harvest.

Under the Estuary and Hybrid Alternatives, reintroducing tidal hydrology to the Capitol Lake Basin would benefit many of the species of importance to the tribes, specifically salmon and shellfish, and potentially other fish and wildlife, as well as plants. Compared to the Estuary Alternative, the Hybrid Alternative would have less of an overall increase in habitat availability and access due to the reflecting pool. Maintenance dredging could result in impacts on tribal resources by causing physical or behavioral responses, or by affecting aquatic habitat, and potentially affecting access to fishing areas within West Bay during maintenance dredging cycles.

Making a determination of significance related to treaty-reserved rights is not part of this discipline report. However, potential impacts and benefits to tribal resources were considered in the decision-making process for identifying the Preferred Alternative, as outlined in detail in Attachment 21 of the Final EIS. Mitigation associated with potential impacts on tribal resources would be addressed directly with the affected tribes during government-to-government consultations as part of the permitting, regulatory, and consultation processes for the selected alternative.

Construction and operation impacts of the No Action and action alternatives are summarized in Tables ES.1 and ES.2.

Table ES.1 Summary of Construction Impacts and Mitigation Measures

	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
Managed Lake Alternative			
Fish – Impacts on fish species, or species group, or aquatic habitat	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No
Wildlife – Impacts on wildlife species or wildlife habitat	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No

	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
Estuary Alternative			
Fish – Impacts on fish species, or species group, or aquatic habitat	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No
Wildlife – Impacts on wildlife species or wildlife habitat	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No
Hybrid Alternative			
Fish – Impacts on fish species, or species group, or aquatic habitat	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No
Wildlife – Impacts on wildlife species or wildlife habitat	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No

Table ES.2 Summary of Operations Impacts (including Benefits) and Mitigation Measures

Impact Summary by Alternative	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
No Action Alternative			
Fish – Impacts on fish species, species group, or aquatic habitat	Less-than-significant Impact	N/A	N/A
Wildlife – Habitat alterations	Less-than-significant Impact	N/A.	N/A
Managed Lake Alternative			
Fish – Impacts on fish species, species group, or aquatic habitat associated with additional permanent overwater and in-water structures and artificial lighting elements	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No

Impact Summary by Alternative	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
Fish – Alterations in lake bathymetry and water depths in the lake associated with dredging, for both the anadromous and freshwater species groups	Minor Beneficial Effect	N/A	N/A
Fish – Alterations in sediment function associated with dam overhaul repairs, including the buttressing berm in Budd Inlet (for the marine species group)	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts (see Section 4.5.8)	No
Wildlife – Conversion of deepwater habitat to wetland habitat areas for some species that utilize open water habitat, such as waterfowl, aerial feeders, and bats	Less-than-significant Impact	BMPs and other measures to avoid and minimize impacts in Section 5.7	No
Wildlife – Alterations in lake bathymetry and water depths in the lake associated with maintenance dredging	Less-than-significant impact	BMPs and other measures to avoid and minimize impacts (See Section 4.5.8)	No
Wildlife – Conversion of deep-water habitat to wetland habitat areas for some species that utilize wetland habitats for habitat or prey, such as raptors and songbirds	Minor Beneficial Effect	N/A	N/A
Estuary Alternative			
Fish – Aquatic habitat alterations related to dam removal (reduction in habitat for native freshwater fish due to transition from freshwater to brackish water in basin)	**Significant Impact**	None	Yes

Impact Summary by Alternative	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
Fish – Conversion of freshwater lake habitat to a tidally influenced brackish estuary, specifically benefitting anadromous fish and marine fish, potentially including ESA-listed Chinook salmon and steelhead trout	**Substantial Beneficial Effect**	N/A	N/A
Fish – Increase in available in-water habitat that would result from dam removal, specifically for anadromous fish and marine fish species, potentially including ESA-listed Chinook salmon and steelhead trout	Moderate Beneficial Effect	N/A	N/A
Wildlife – Habitat alteration (impacts on bats)	**Significant Impact**	None	Yes
Wildlife – Habitat alteration (impacts on aerial feeders)	Less-than-significant	None	No
Wildlife – Large expansion of suitable habitat within the estuary for shellfish	Moderate Beneficial Effect	N/A	N/A
Wildlife – Increase in suitable habitat and changes in the types of prey available for shorebirds and wading birds from conversion to estuarine habitat	**Substantial Beneficial Effect**	N/A	N/A
Wildlife – Increased system diversity and range of foraging opportunities for waterfowl	Moderate Beneficial Effect		

Impact Summary by Alternative	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
Wildlife – Increased habitat available for raptors and songbirds	Minor Beneficial Effect	N/A	N/A
Wildlife – Potential for increased salmon prey base for ESA-listed orcas	Minor Beneficial Effect	N/A	N/A
Hybrid Alternative			
Fish – Aquatic habitat alterations related to dam removal (reduction in habitat for native freshwater fish due to transition from freshwater to brackish water in basin)	**Significant Impact**	None	Yes
Fish – Conversion of freshwater lake habitat to a tidally influenced brackish estuary, benefitting anadromous fish and marine fish, potentially including ESA-listed Chinook salmon and steelhead trout	Moderate Beneficial Effects	N/A	N/A
Fish – Increase in available in-water habitat that would result from dam removal, specifically for anadromous fish and marine fish species	Moderate Beneficial Effects	N/A	N/A
Wildlife – Habitat alteration (impacts on bats)	**Significant Impact**	None	Yes
Wildlife – Habitat alteration (impacts on aerial feeders)	Less than significant	None	No
Wildlife – Large expansion of suitable habitat within the estuary for shellfish	Moderate Beneficial Effects	N/A	N/A

Impact Summary by Alternative	Impact Finding	Minimization and Other Mitigation Measures	Significant and Unavoidable Adverse Impact
Wildlife – Increase in suitable habitat and changes in the types of prey available for shorebirds and wading birds from conversion to estuarine habitat	Moderate Beneficial Effects	N/A	N/A
Wildlife – Increased system diversity and range of foraging opportunities for waterfowl	Moderate Beneficial Effect	N/A	N/A
Wildlife – Increased habitat available for raptors and songbirds	Minor Beneficial Effects	N/A	N/A
Wildlife – Potential for increased salmon prey base for ESA-listed orcas	Minor Beneficial Effects	N/A	N/A

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List of Acronyms and Abbreviations

Acronyms/ Abbreviations	Definition
BMP	best management practice
BOD	biological oxygen demand
C-CAP	Coastal Change Analysis Program
cfs	cubic feet per second
CMP	corrugated metal pipe
Corps	U.S. Army Corps of Engineers
CY	cubic yards
DAHP	Washington State Department of Archaeology and Historic Preservation
dB	decibel
DNR	Washington Department of Natural Resources
DO	dissolved oxygen
Ecology	Washington Department of Ecology
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
Enterprise Services	Washington State Department of Enterprise Services
ESA	Endangered Species Act
g	grams
GIS	geographic information system
GMA	Growth Management Act
HDPE	High Density Polyethylene
HPA	Hydraulic Project Approval
IUCN	International Union for Conservation of Nature
MHHW	mean higher high water
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

Acronyms/ Abbreviations	Definition
NWIFC	Northwest Indian Fisheries Commission
OMC	City of Olympia Municipal Code
OWS	overwater structure
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PHS	Priority Habitats and Species
ppt	parts per thousand
RCW	Revised Code of Washington
RMS	root mean square
SEL	sound exposure level
SEPA	State Environmental Policy Act
SF	square foot/feet
SMP	Shoreline Master Program
SPL	sound pressure level
SPSSRG	South Puget Sound Salmon Recovery Group
SWIFD	Statewide Integrated Fish Distribution
TMC	Tumwater Municipal Code
TMDL	Total Maximum Daily Load
TRPC	Thurston Regional Planning Council
U&A	Usual and Accustomed
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WWTIT	Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes

1.0 Introduction and Project Description

1.1 PROJECT DESCRIPTION

The Capitol Lake – Deschutes Estuary includes the 260-acre Capitol Lake Basin, located on the Washington State Capitol Campus, in Olympia, Washington. The waterbody has long been a valued community amenity. Capitol Lake was formed in 1951 following construction of a dam and provided an important recreational resource. Historically, the Deschutes Estuary was used by local tribes for subsistence and ceremonial purposes. Today, the expansive waterbody is closed to active public use. There are a number of environmental issues including the presence of invasive species, exceedances of water quality standards, and inadequate sediment management.

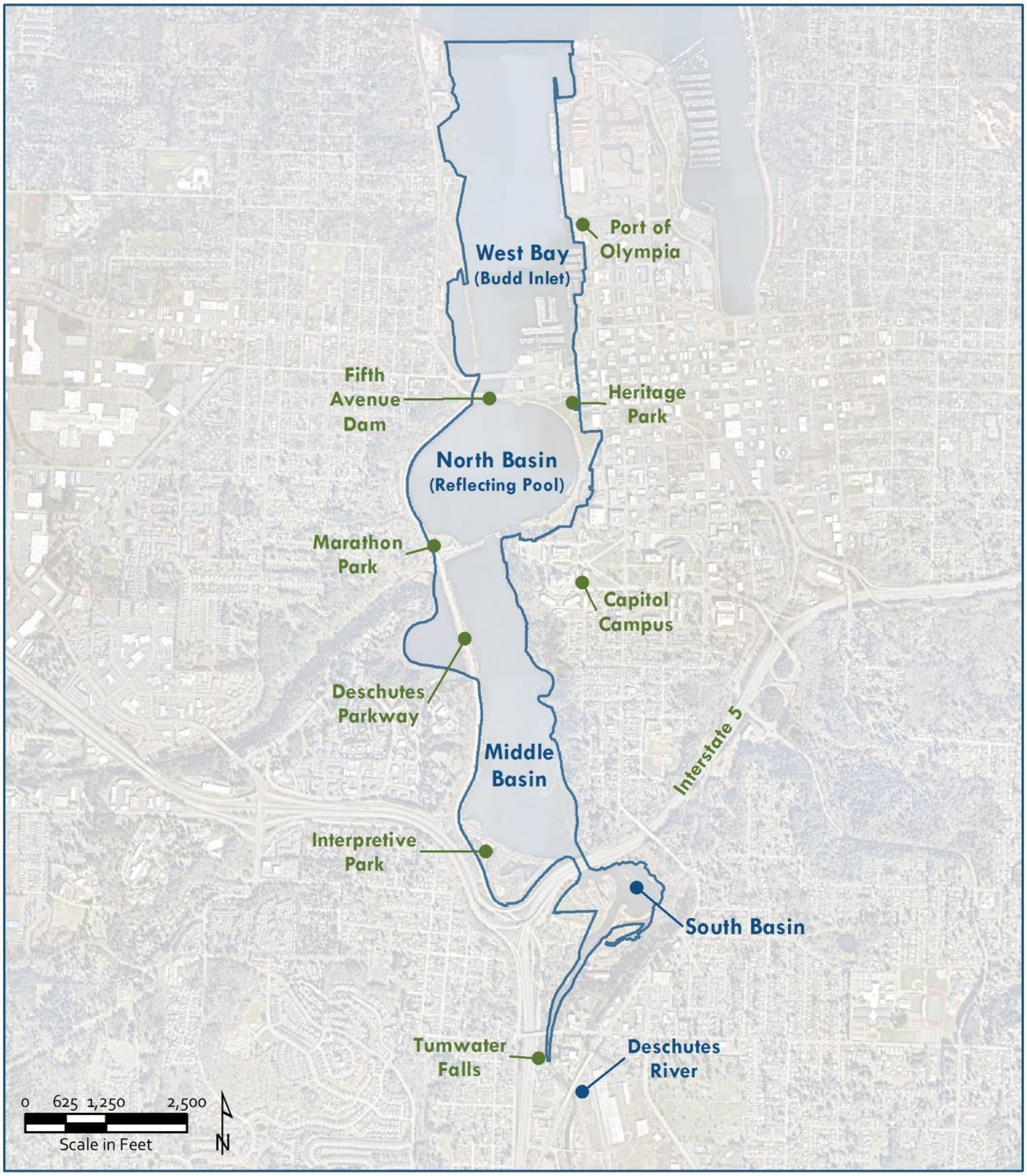
The Washington State Department of Enterprise Services (Enterprise Services) is responsible for the stewardship, preservation, operation, and maintenance of the Capitol Lake Basin. The 260-acre Capitol Lake Basin is maintained by Enterprise Services under long-term lease agreement from the Washington Department of Natural Resources.

In 2016, as part of Phase 1 of long-term planning, a group of stakeholders representing a broad range of interests, in collaboration with the state, identified shared goals for long-term management and agreed an Environmental Impact Statement (EIS) was needed to evaluate a range of alternatives and identify a Preferred Alternative. In 2018, the state began the EIS process. The Draft EIS was published on June 30, 2021, and evaluated four alternatives: a Managed Lake, Estuary, Hybrid, and a No Action Alternative.

The long-term management alternatives are evaluated against the shared project goals of improving water quality, managing sediment accumulation and future deposition, improving ecological functions, and enhancing community use of the resource. Refer to Figure 1.1 for the project area for long-term management.

Within the Final EIS, Enterprise Services has identified the Estuary Alternative as the preferred environmentally and economically sustainable long-term management alternative for the Capitol Lake – Deschutes Estuary. The EIS process has maintained engagement with the existing Work Groups, which include the local governments, resource agencies, and tribe. It also provides for expanded engagement opportunities for the public, such as a community sounding board.

Figure 1.1 Project Area



1.2 SUMMARY OF PROJECT ALTERNATIVES

1.2.1 Managed Lake Alternative

The Managed Lake Alternative would retain the 5th Avenue Dam and Bridge in its existing configuration. The 5th Avenue Dam would be overhauled to significantly extend the serviceable life of the structure. The reflecting pool within the North Basin would be maintained, and active recreational use would be restored in this area. Sediment would be managed through initial construction dredging and recurring maintenance dredging in the North Basin only. Sediment from construction dredging would be used to create habitat areas in the Middle Basin to support improved ecological function, habitat complexity, and diversity. Sediment would continue to accumulate and over time would promote a transition to freshwater wetlands in the South and Middle Basins. Boardwalks, a dock, and a boat launch would be constructed for community use.

This project would also construct a new, approximately 14-foot-wide non-vehicular bridge south of the existing 5th Avenue Bridge to provide a dedicated recreational trail connection.

Adaptive management would be needed to maintain water quality, improve ecological functions, and manage invasive species.

1.2.2 Estuary Alternative

Under the Estuary Alternative, the existing 5th Avenue Dam and Bridge would be removed, and an approximately 500-foot-wide (150-meter-wide) opening would be established in its place. This would reintroduce tidal hydrology to the Capitol Lake Basin, returning the area to estuarine conditions where saltwater from Budd Inlet would mix with freshwater from the Deschutes River. Sediment would be managed through initial construction dredging in the Capitol Lake Basin and recurring maintenance dredging within West Bay. Dredged materials from construction dredging would be used to create habitat areas in the Middle and North Basins to promote ecological diversity, though tideflats would be the predominant habitat type. Boardwalks, a dock, and a boat launch would be constructed for community use. This alternative also includes stabilization along the entire length of Deschutes Parkway to avoid undercutting or destabilization from the tidal flow. Existing utilities and other infrastructure would be upgraded and/or protected from reintroduced tidal hydrology and saltwater conditions.

The Estuary Alternative has been updated in the Final EIS to include a new 5th Avenue Bridge that would be constructed south of the existing 5th Avenue Dam and Bridge. The new bridge would include a vehicle lane, bike lane, and sidewalk in each direction, with the sidewalk on the south side providing a dedicated recreational trail connection. This bridge would be constructed and connected to the transportation system before the existing 5th Avenue Dam and Bridge are removed.

Adaptive management plans would be developed to improve ecological functions and manage invasive species during the design and permitting process.

1.2.3 Hybrid Alternative

Under the Hybrid Alternative, the existing 5th Avenue Dam and Bridge would be removed, and an approximately 500-foot-wide (150-meter-wide) opening would be established in its place. Tidal hydrology would be reintroduced to the western portion of the North Basin and to the Middle and South Basins. Within the North Basin, a curved and approximately 2,600-foot-long (790-meter-long) barrier wall with a walkway would be constructed to create an approximately 45-acre reflecting pool adjacent to Heritage Park. The reflecting pool of the Hybrid Alternative has been updated in the Final EIS to be groundwater-fed, rather than saltwater. Construction and maintenance of this smaller reflecting pool, in addition to restored estuarine conditions in part of the Capitol Lake Basin, gives this alternative its classification as a hybrid.

Sediment would be managed through initial construction dredging in the Capitol Lake Basin and recurring maintenance dredging within West Bay. In the Middle and North Basins, constructed habitat areas would promote ecological diversity, though tideflats would be the predominant habitat type. Boardwalks, a dock, and a boat launch would be constructed for community use. This alternative also includes stabilization along the entire length of Deschutes Parkway to avoid scour or destabilization. Existing utilities and other infrastructure would be upgraded and/or protected from reintroduced tidal hydrology and saltwater conditions.

The Hybrid Alternative would also construct a new 5th Avenue Bridge, as described for the Estuary Alternative, prior to removing the existing 5th Avenue Dam and Bridge.

Adaptive management plans would be needed to improve ecological functions, manage invasive species, and maintain water quality in the freshwater reflecting pool.

1.2.4 No Action Alternative

The No Action Alternative represents the most likely future expected in the absence of implementing a long-term management project. The No Action Alternative would persist if funding is not acquired to implement the Preferred Alternative. A No Action Alternative is a required element in a State Environmental Policy Act (SEPA) EIS and provides a baseline against which the impacts of the action alternatives (Managed Lake, Estuary, Hybrid) can be evaluated and compared.

The No Action Alternative would retain the 5th Avenue Dam in its current configuration, with limited repair and maintenance activities, consistent with the scope and scale of those that have received funding and environmental approvals over the past 30 years. In the last 30 years, the repair and maintenance activities have been limited to emergency or high-priority actions, which occur sporadically as a result of need and funding appropriations.

Although Enterprise Services would not implement a long-term management project, current management activities and ongoing projects in the Capitol Lake Basin would continue. Enterprise Services would continue to implement limited nuisance and invasive species management strategies.

In the absence of a long-term management project, it is unlikely that Enterprise Services would be able to procure funding and approvals to manage sediment, improve water quality, improve ecological functions, or enhance community use. The No Action Alternative does not achieve the project goals.

1.3 CONSTRUCTION METHODS FOR THE ACTION ALTERNATIVES

This impact analysis relies on the construction method and anticipated duration for the action alternatives, which are described in detail in Chapter 2 of the EIS.

2.0 Regulatory Context

2.1 RESOURCE DESCRIPTION

This discipline report describes the following important ecosystem resources— fish and wildlife, and their habitats. An ecosystem is a biological community interacting with its physical and chemical environment as an integrated, dynamic unit. Ecosystems are made up of living organisms, including humans, and the environment they inhabit. Understanding this relationship is integral to the environmental review process. Various federal, state, and local regulations, including the Washington SEPA, require that the effects of a proposed project on ecosystem structure, function, and process be evaluated in an EIS. This report is organized into two sections by ecosystem resource: (1) fish and fish habitat, and (2) wildlife and wildlife habitat. The three major groups of fish species evaluated, based on species life history, include anadromous fish, freshwater fish, and marine fish. Anadromous fish include those listed under the Endangered Species Act (ESA), other salmonids, and non-salmonid anadromous fish. Freshwater fish include both native fish and those that are exotic or non-native. Wildlife species addressed in this report include shellfish, birds, bats, and mammals (freshwater aquatic and marine).

This report also provides a discussion of tribal resources. Additional information on tribal resources is included in Section 4.3 of the *Cultural Resources Discipline Report* (ESA and NW Vernacular 2022) and in the *Economics Discipline Report* (ECONorthwest 2022), where ecosystem services are discussed. For the purposes of this Draft EIS, the term tribal resources refers to tribal fishing and gathering practices and treaty rights, specifically, the collective rights and access to traditional areas associated with a tribe's sovereignty or formal treaty rights. These resources may include fish, wildlife or plants used for commercial, subsistence, and ceremonial purposes.

The project will require federal permits from the U.S. Army Corps of Engineers (Corps). The Corps, as federal lead agency, will conduct a review of the Proposed Action under the National Environmental Policy Act (NEPA). Pursuant to NEPA, the Corps will consult under Section 106 of the National Historic Preservation Act with tribes, the Washington State Department of Archaeology and Historic Preservation (DAHP), and the applicant. The Corps is expected to assess potential impacts of the Proposed Action on tribal resources, including potential impacts related to tribal sovereignty and treaty rights. Also pursuant to NEPA, the Corps is expected to consult under Section 7 of the federal

Endangered Species Act with the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries.

2.2 RELEVANT LAWS, PLANS, AND POLICIES

Fish and wildlife and their habitats are protected by a variety of federal and state laws, plans, and policies (Section 2.2.1) and local plans and policies (Section 2.2.2).

2.2.1 Federal and State

Several federal and state regulations, plans, and policies influence planning, land use, and management activities that can impact fish and wildlife species and their habitats within the study area. Tables 2.1 and 2.2 summarize applicable federal and state regulations and policies.

Table 2.1 Federal Laws, Plans, and Policies

Regulatory Program or Policies	Lead Agency	Description
Medicine Creek Treaty of 1854	U.S. Government & Native American groups	Treaty between U.S. Government and certain Native American groups with 13 articles. Articles include, but are not limited to, defining lands ceded by signatories to the U.S. Government, securing the rights of signatories for taking fish at usual and accustomed grounds and stations, and creating reservations.
Federal Endangered Species Act (ESA)	National Marine Fisheries Service (NMFS); USFWS	Provides for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The ESA prohibits importing, exporting, taking, possessing, selling, and transporting endangered and threatened species (with certain exceptions). It also provides for the designation of critical habitat and prohibits the destruction of that habitat. All projects that require federal permits, federal funding or federal land must comply with the ESA. The ESA pertains to all federally listed threatened and endangered species and critical habitats.
Magnuson-Stevens Fishery Conservation and Management Act (MSA) - Public Law 104-297, October 11, 1996, as amended	NMFS	Requires federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The EFH designation for the Pacific salmon fishery (Chinook, coho, and pink salmon) includes all those streams, lakes, ponds, wetlands, and other waterbodies, currently or historically accessible to salmon in Washington, except above identified impassable barriers. In addition to Pacific salmon, EFH has been designated for groundfish and coastal pelagic species.

Regulatory Program or Policies	Lead Agency	Description
Marine Mammal Protection Act	NMFS; USFWS	Protects all marine mammals and prohibits, with certain exceptions, the take of marine mammals in U.S. waters.
Fish and Wildlife Coordination Act	NMFS; USFWS; Washington Department of Fish and Wildlife (WDFW)	Requires that federal agencies consult with the USFWS, NMFS, and state wildlife agencies for activities that affect, control, or modify waters of any stream or bodies of water, in order to minimize the adverse impacts of such actions on fish and wildlife resources and habitat.
Recovery Plan for Southern Resident Killer Whales	NMFS	This plan identifies a range of actions that will contribute to recovery of Southern Resident killer whales. The plan includes efforts on the local, state and regional levels to address recovery of other species (particularly salmon), cleanup of Puget Sound and management of local resources.
Bald and Golden Eagle Protection Act	USFWS	Protects bald and golden eagles from the unauthorized capture, purchase, or transportation of the birds, their nets, or their eggs.
Coastal Zone Management Act (CZMA)	Administered by Washington Department of Ecology (Ecology)	Voluntary state–federal partnership that encourages states to adopt management programs to meet the federal goals of protection, restoration, and appropriate development of coastal zone resources. In Washington, primarily implemented through the Clean Water Act process (discussed under *State* below). Includes the "federal consistency" provision, which gives states a strong voice in federal agency decision-making and guidelines.
Executive Order 12962 (Recreational Fisheries)	USFWS	Mandates federal agencies, to the extent permitted by law and where practical, to improve the "quantity, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreational fishing opportunities."
Migratory Bird Treaty Act	USFWS	Protects migratory birds by prohibiting private parties (and federal agencies in certain judicial circuits) from intentionally taking, selling, or conducting other activities that would harm migratory birds, their eggs, or nests (such as the removal of an active nest or nest tree), unless the Secretary of the Interior authorizes such activities under a special permit.

Table 2.2 State Laws, Plans, and Policies

Regulatory Program or Policies	Lead Agency	Description
Washington State Endangered Species Act	WDFW	Oversees the listing and recovery of those species in danger of being lost in the state. Pertains to all state-listed threatened and endangered species.
State Hydraulic Code (Washington Administrative Code [WAC] 220-660)	WDFW	Regulates hydraulic projects (construction or performance of work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state) by requiring a Hydraulic Project Approval (HPA) for all such projects. The purpose of the HPA is to ensure that construction or performance of work is done in a manner that protects fish life.
Shoreline Management Act	Ecology	Requires local jurisdictions to implement shoreline master programs to "prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." Shorelines are defined as marine waters, streams, and rivers with greater than 20 cubic feet per second (cfs) mean annual flow; lakes 20 acres or larger; upland areas called shorelands that extend 200 feet landward from the edge of these waters; biological wetlands and river deltas connected to these waterbodies; and some or all of the 100-year floodplain, including all wetlands. Implemented via the local Shoreline Master Programs (SMPs).
Growth Management Act (Revised Code of Washington [RCW], Chapter 36.70A)	Department of Commerce	The Growth Management Act (GMA) requires local jurisdictions to designate and protect critical areas, including fish and wildlife habitat conservation areas, are critical areas, in order to wisely use and protect the state's resources, including aquatic resources. See Critical Areas References in Table 2.3 for more detail.

2.2.2 Local

The study area includes lands located in the cities of Olympia and Tumwater. These municipalities have developed comprehensive plans, zoning, shoreline management plans, and ordinances for environmentally critical areas to direct growth and development within their jurisdictions, and have codified regulations in their respective municipal codes. Table 2.3 presents a summary of applicable local laws, plans, and policies.

Table 2.3 Local Laws, Plans, and Policies

Regulatory Program or Policies	Lead Agency	Description
Deschutes River Coho Salmon Biological Recovery Plan	Squaxin Island Tribe	Provides an analysis and recommendations for the priority reaches in the watershed and priority types of restoration and protection actions to implement.
City of Olympia Municipal Code (OMC) 18.32 - Environmentally Critical Areas Code (2016)	City of Olympia	OMC 18.32 governs areas of Olympia that provide critical environmental functions and values including critical aquifer recharge areas (drinking water protection areas), fish and wildlife species, streams and riparian areas, wetlands, floodplains, and geologic hazard areas (i.e., landslides, erosion hazards).
OMC 16.70 Flood Damage Prevention (2019)	City of Olympia	OMC 16.70 promotes public health, safety, and general welfare through regulating activities within flood hazard areas.
OMC 16.60 Tree, Soil, and Native Vegetation Protection and Replacement	City of Olympia	Regulates tree, soil, and native vegetation removal and protection.
Shoreline Master Program (SMP) (2015)	City of Olympia	The SMP provides goals, policies, and regulations for shoreline use and protection, and establishes a permit system for administering the program. The goals, policies, and regulations are tailored to the specific geographic, economic, and environmental needs of the City of Olympia and its varied shorelines.
Shoreline Master Program (2014, last updated 2019)	City of Tumwater	The SMP provides goals, policies, and regulations for shoreline use and protection, and establishes a permit system for administering the program. The goals, policies, and regulations are tailored to the specific geographic, economic, and environmental needs of the City of Tumwater and its varied shorelines.
Tumwater Municipal Code (TMC) 16.04, 16.12-16.32 Environment	City of Tumwater	TMC 16 governs areas of Tumwater that provide critical environmental functions including wetlands, fish and wildlife habitat areas, geologic hazard areas (i.e., erosion hazards), floodplains, and wellhead protection areas.

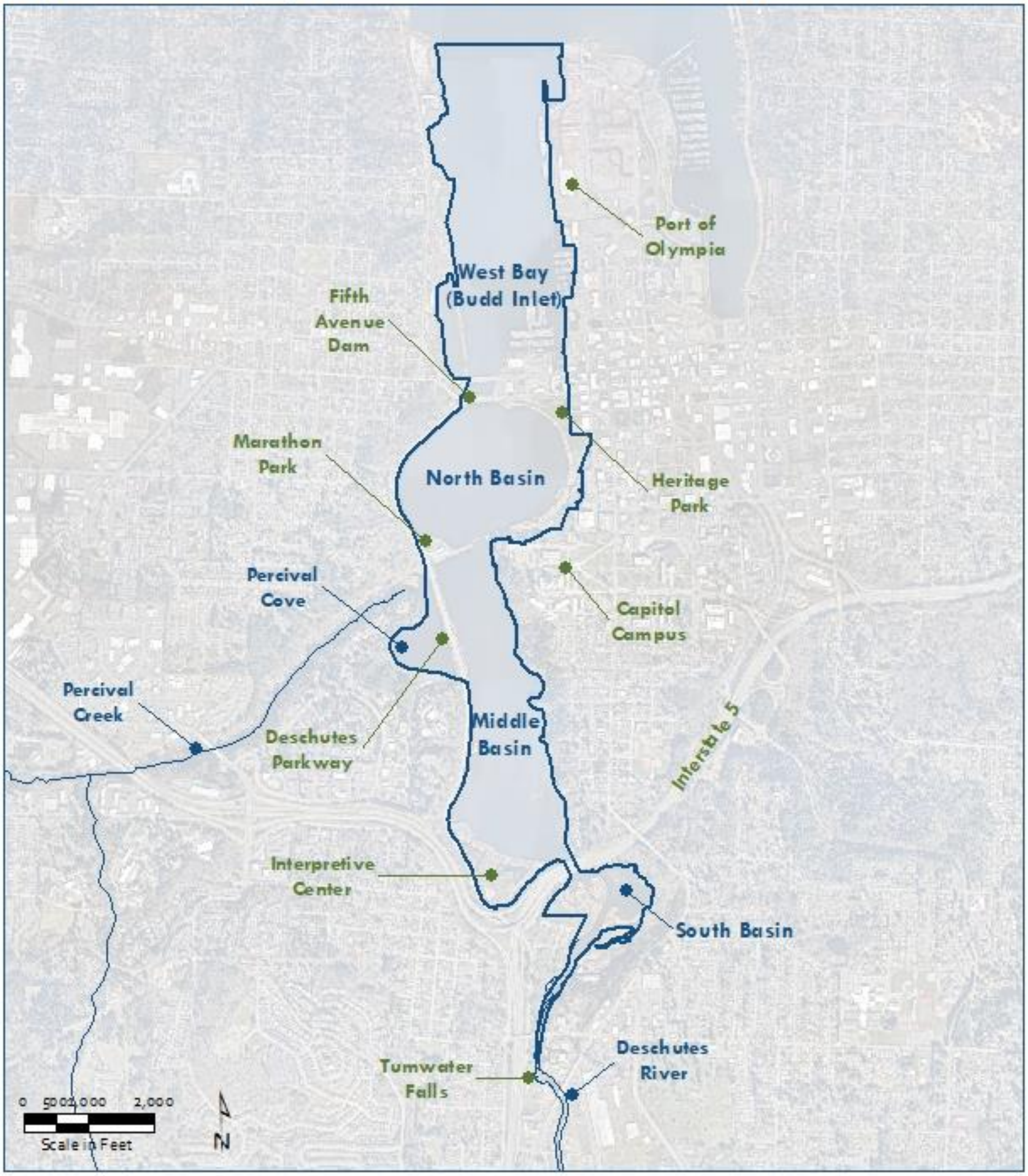
Regulatory Program or Policies	Lead Agency	Description
TMC 16.08 Protection of Trees and Vegetation	City of Tumwater	Regulates the removal and protection of trees and native vegetation.
2016–2036 Comprehensive Plan (2016)	City of Tumwater	The Comprehensive Plan describes the community's long-term vision and goals, including its vision for the natural environment, future land use, recreation, and other infrastructure.

3.0 Methodology

3.1 SELECTION OF THE STUDY AREA

The primary study area for fish and wildlife and their habitats is shown in Figure 3.1. The primary study area is based on the area where fish and wildlife species or habitats could be most directly affected by the construction or operation of the project alternatives. The study area includes both the area where construction would occur under each alternative, as well as the areas that support species that could be affected by the project, defined as the Capitol Lake Basin (including Percival Cove), Deschutes River up to the base of the Tumwater Falls, West Bay of Budd Inlet, and Percival Creek upstream to where modeling indicates that geomorphic changes or tidal influence could occur. The study area also includes riparian, wetland, and contiguous terrestrial habitats along the shorelines of the Capitol Lake Basin and West Bay. The southern boundary is generally the base of Tumwater Falls, and the northern limit is the northern end of West Bay. Although the project could have minor effects on hydrology and water quality north of West Bay, in the greater Budd Inlet, and into East Bay, the nature and magnitude of any such changes are not expected to adversely impact fish and wildlife species and habitats. See the *Water Quality Discipline Report* (Herrera 2022a).

Figure 3.1 Study Area for Fish and Wildlife



Legend

Project Area

3.2 DATA SOURCES AND COLLECTION

Data sources used for the fish and wildlife analysis include available scientific literature, technical reports, and data from various federal, tribal, state, and local agencies. These sources were used to identify fish and wildlife species, as well as associated habitats, that occur in the study area. With this information, potential effects of the proposed project on species presence, distribution, abundance, and habitat conditions were assessed. This assessment was based on peer-reviewed literature and other documents identified as "best available science" during the Phase 1 process (2016), which was supplemented during the 2021–2022 document finalization process, which includes but is not limited to the sources listed below:

- NOAA C-CAP Land Cover Atlas (2016)
- USFWS Information and Planning and Consultation (IPaC) System
- WDFW Species and Habitat Information (2022)
- USFWS National Wetlands Inventory, Wetlands Mapper (2019)
- WDFW 2017-18 Final Hatchery Escapement Report (2020b)
- WDFW Forage Fish Spawning Online Mapper (2020c)
- WDFW SalmonScape Database (2020d)
- WDFW Priority Habitats and Species (PHS) database (2021)
- Tumwater Falls Hatchery Genetics Management Plans (WDFW 2005)
- Implications of Capitol Lake Management for Fish and Wildlife (Hayes et al. 2008)
- Washington Department of Natural Resources (DNR) Natural Heritage Program (2020)
- Ecology Coastal Atlas Map and Database (2020b)
- Statewide Integrated Fish Distribution
- Statewide Integrated Fish Distribution (SWIFD) (NWIFC 2020b)
- Capitol Lake Bathymetric Survey (eTrac 2020)
- Salmon Habitat Protection and Restoration Plan for Water Resource Inventory Area 13, Deschutes (TCDLE 2004)
- City of Olympia Storm and Surface Water Plan (2018)
- City of Olympia Critical Area and Shoreline geographic information system (GIS) data (2019)
- City of Olympia West Bay Environmental Restoration Assessment (Coast and Harbor Engineering (2016)
- City of Tumwater Draft Urban Forestry Management Plan (March 2020)

- Lacey, Olympia, and Tumwater Shoreline Analysis & Characterization Report (ESA Adolfson 2008)
- Thurston County Natural Resources GIS data layers (2019)
- Thurston County Regional Planning Council (TRPC) Shoreline Inventory (2008)
- Salmon and Steelhead Habitat Limiting Factors reports for Water Resource Inventory Area 13 (Haring and Konovsky 1999)
- Deschutes River Coho Salmon Biological Recovery Plan (Confluence 2015)
- Percival Creek Comprehensive Drainage Basin Plan (Olympia 1993)

Additional sources were reviewed for the Final EIS in response to comments on the Draft EIS, and summarized in annotated bibliographies included as appendices to this report, as follows:

- **Appendix A** – Annotated Bibliography Addressing Salmon Ecology Topics Related to CLDE Long-Term Management Draft EIS Comments
- **Appendix B** – Annotated Bibliography Addressing Bat Ecology Related to CLDE Long-Term Management Draft EIS Comments

3.3 ANALYSIS OF IMPACTS

A large number and variety of fish and wildlife species utilize the aquatic and terrestrial habitats within the study area. Potential impacts from the project alternatives include both short- and long-term impacts on these species, as well as their habitats. Negative impacts on fish and wildlife species due to temporary construction or loss of suitable or key habitats for a fish (species groups) and wildlife species (indicator species) are considered adverse impacts. The relative magnitude of adverse impacts is categorized as "**less-than-significant**" or "**significant**." Conversely, substantial increases in the quality and/or quantity of suitable or key habitats for a fish (species group) and wildlife species (indicator species) are considered beneficial effects of an alternative. While the primary focus of the SEPA analysis is the identification of adverse impacts, the analysis also evaluated the potential magnitude of beneficial effects. Long-term beneficial effects were considered **minor**, **moderate**, or **substantial** incorporating both quantitative and qualitative factors as well as best professional judgment.

Detailed information on the presence, distribution, and abundance of individual fish and wildlife species in the study area is variable, and lacking for some species. In addition, there are a large number of species in the study area, making it difficult to analyze project effects on each individual species. Therefore, it is useful to focus on specific species groups (based on similar habitat preferences) or indicator species (specifically selected for this project) whose response to impacts is representative of a larger group of species. Potential impacts on fish species and habitat were generally evaluated by species groups, while the potential impacts on wildlife species and habitat were based more on indicator species. Note that some individual species have more intrinsic and societal value than other species. For example, adverse impacts and beneficial effects to ESA-listed species are given the most consideration, followed by other non-ESA listed native species. A species-specific evaluation for

ESA-listed species, state priority species, and species of local concern would occur during permitting of the selected alternative.

Impacts on fish species groups and wildlife indicator species are based on known occurrences in the study area, life history requirements, and the potential changes in habitat condition, extent, and availability under each alternative. For fish, the analysis considered changes in wetted area, bathymetry, salinity, tidal inundation, freshwater inputs, water quality, and sediment distribution. For wildlife, the analysis also considered changes in the availability of cover, food, predator-prey relationships, and breeding sites.

3.3.1 Identification of Construction Impacts

Construction impacts are the temporary effects related to construction disturbance. Potential long-term impacts on fish and wildlife from permanent habitat changes and recurring maintenance dredging are addressed under *Operational Impacts*.

Project construction is anticipated to last 4 to 8 years, depending on the alternative, and would entail multiple in-water work seasons. Pursuant to federal, state and local laws, the project must include best management practices (BMPs) to avoid and minimize construction impacts. The affected habitats generally would revert to their pre-construction condition following completion of the project either through natural processes, active restoration, or some combination; however, the time-frame (temporal aspect) of recovery following construction is also considered in the impact analysis.

The primary construction elements that could affect fish and wildlife include the following:

- Activities related to initial dredging and creation of habitat areas in the Capitol Lake Basin.
- In-water construction (e.g., 5th Avenue Dam repair or removal, new non-vehicular bridge or new, replacement 5th Avenue Bridge, boardwalks, dock, boat launch).
- Construction activities that include noise-generating activities (e.g., pile driving) and/or that create visual disturbances.

Impacts are analyzed based on the known relationships between construction elements (e.g., turbidity and construction noise) and the effects on fish and wildlife (e.g., avoidance, decreased foraging activity). As described previously, the analysis focuses on the effects of project construction on representative fish and wildlife species groups and indicator species. The analysis considered construction timing, duration, methods, and BMPs and their relative implication for species and habitats under each alternative. Construction impacts were estimated based on the conceptual design for each alternative.

For the fish and wildlife analysis, the magnitude of short-term (construction) impacts is considered significant or less-than-significant, as follows.

Impacts are considered significant if they:

- Result in large-scale take (mortality, injury, or deleterious behavioral changes on more than a few individual organisms) on fish and wildlife species listed under the federal Endangered Species Act (Threatened or Endangered) or similar effects on those species under the Washington State Endangered Species Act (Threatened, Endangered, Sensitive, or Candidate); or
- Eliminates, or makes non-viable, a species group or species of regional importance within the Capitol Lake Basins or West Bay through the loss of suitable habitat; or
- Substantially impact the movement of native resident or migratory fish or wildlife species or impair the use of fish spawning or wildlife breeding areas, through large-scale activities that either precludes access to such for more than 2 years or directly eliminates those habitats that support spawning and breeding for a species group.

Impacts are considered less-than-significant if they:

- Do not result in large-scale take (mortality, injury, or deleterious behavioral changes on more than a few individuals) on fish and wildlife species listed under the federal Endangered Species Act (Threatened or Endangered) or similar effects on those species under the Washington State Endangered Species Act (Threatened, Endangered, Sensitive, or Candidate) and where the nature, magnitude, and duration of the effect are limited to a small number of individual organisms of a given fish and wildlife species, but do not substantially affect the reproduction, growth, or persistence of a species; or
- Have a short-term (less than 2 years) impact on the movement of native resident or migratory fish or wildlife species, or their use of fish spawning areas or wildlife breeding areas, but do not substantially affect the reproduction, growth, or persistence of a species.

3.3.2 Identification of Operational Impacts

Operational impacts are the long-term or permanent effects related to the operation of the project. Operational effects analyze the projected outcome of each alternative and the changes to habitat and the corresponding effects to fish and wildlife species. Both long-term adverse impacts and beneficial effects associated with fish and wildlife are evaluated based on expected changes in ecological functions and processes within the study area. The primary elements of the alternatives that would have the most effect on fish and wildlife include the following:

- 5th Avenue Dam repair or removal (e.g., freshwater or estuarine system)
- Impacts of new in-water and overwater structures (e.g., boardwalks, dock, boat launch, non-vehicular bridge, new 5th Avenue Bridge)
- Recurring disturbance related to maintenance dredging

Assessments of potential adverse impacts and beneficial effects to fish and wildlife and their habitats are based on many factors including:

- The type, extent, and magnitude of habitat change relative to existing conditions, including temporal effects (e.g., how long would it take for each habitat to reach some level of relative stability).
- Changes in hydrology and sediment transport as indicated based on modeling of the alternatives and their specific design components.
- Expected changes in salinity and habitat type.
- Expected changes in water quality and aquatic vegetation, including during maintenance dredging.

The potential impacts and benefits of the alternatives on fish and wildlife are described by estimating the type, extent, and magnitude of habitat changes relative to existing conditions, and correlating those changes to the species groups and indicator species that occupy or are associated with each habitat type; no species-specific models were developed. The potential changes to vegetation in the study area are also explained and where possible, quantified. Changes in vegetation, water flow, salinity, and tidal fluctuation have a corresponding effect on species occurrence and densities, and affect wildlife use of those habitats. There is always uncertainty in predicting outcomes of effects to complex ecological systems, so the relative uncertainty is also acknowledged.

For the fish and wildlife analysis, the magnitude of long-term (operational) impacts is considered significant or less-than-significant, as follows.

Impacts are considered significant if they:

- Result in large-scale take (mortality, injury, or deleterious behavioral changes on more than a few individual organisms) on fish and wildlife species listed under the federal Endangered Species Act (Threatened or Endangered) or similar effects on those species under the Washington State Endangered Species Act (Threatened, Endangered, Sensitive, or Candidate); or
- Eliminates, or makes non-viable, a species group or species of regional importance within the Capitol Lake Basins or West Bay through the loss of suitable habitat, including habitat that supports reproduction, growth and feeding, or migration; or
- Conflict with the provisions of an approved local, regional, or state habitat conservation plan and/or regional salmon recovery plan.

Impacts are considered less-than-significant if they:

- Do not result in large-scale take (mortality, injury, or deleterious behavioral changes on more than a few individuals) on fish and wildlife species listed under the federal Endangered Species Act (Threatened or Endangered) or similar effects on those species under the Washington State Endangered Species Act (Threatened, Endangered, Sensitive, or Candidate) and where the nature, magnitude, and duration of the effect are limited to a small number of individual organisms of a given fish and wildlife species, but do not substantially affect the reproduction, growth, or persistence of a species; or

- Have minor long-term alterations in the environment that do not reduce the habitat quality or quantity of a fish and wildlife species group or indicator species to the point where the species or species group is extirpated from the study area.

4.0 Affected Environment

4.1 FISH AND AQUATIC HABITAT

Capitol Lake was transformed into a fresh waterbody in 1951 when a dam and associated tide gate were constructed at the mouth of the Deschutes River to form a reflecting pool for the Capitol Building. Prior to this time, the Deschutes River flowed to Budd Inlet, with the current-day Capitol Lake Basin consisting of estuary habitat, including substantial tideflats (Figure 4.1). Prior to the dam construction and until 1954, anadromous fish were able to travel upstream from Budd Inlet up to Tumwater Falls, a natural fish passage barrier that historically restricted the distribution of anadromous fish to the lower 2 miles of the Deschutes River. If any spawning of native salmonids occurred below the falls, this would have likely been minimal due to the small amount of suitable, freshwater spawning habitat that would have existed between the falls and the estuary. Anecdotally, there are reports that fly fishing for salmon and trout species within the estuary was relatively common prior to dam installation. In addition to using the lower Deschutes River for spawning and rearing, a number of salmon species spawned in Percival Creek and used the estuary for a gradual transition from freshwater to saltwater.

Sediment from the Deschutes River, and to a lesser extent Percival Creek, was transported into Puget Sound, and natural tidal exchanges supported water quality. The marine shoreline of West Bay provided tideflats and productive habitat for macroinvertebrates and forage fish, both important to the diets of salmon.

Construction of the 5th Avenue Dam limited anadromous fish passage, created a barrier to tidal exchange, and altered natural hydrological and sediment transport processes. For anadromous fish outmigrating from freshwater as juveniles or returning to freshwater as adults, the dam includes two flood control discharge channels and a fishway channel to provide suitable water depth, velocity, and jump conditions. When originally constructed, the tide gate and fishway could potentially delay the upstream migration of adult salmonids during low tides (Haring and Konovsky 1999) and restrict the movement of smaller fish (i.e., less than 6 inches long). This occurred when the lower lake levels in winter and the relatively high elevation of the fish ladder limited movement into and out of the lake to times when the tide gate was open and flow conditions were sufficient to allow these relatively weak-swimming fish to move freely. In 2002, the fishway was retrofitted to meet WDFW fish passage criteria and is considered 100% passable (WDFW Site ID: 970005).

Figure 4.1 Historical Condition of Capitol Lake Basin

1873 1941

The alteration of natural hydrological and sediment transport processes following dam construction resulted in substantial filling of the lake basin with fine sediment from upstream reaches of the Deschutes River and created a shallow freshwater lake. These changes in the basin, in combination with nutrient sources from the Deschutes River, contributed to excess accumulations of phosphorus (contributing to increased algae and invasive plant growth) in the basin, although more recent water quality data indicate an improving trend in phosphorous loading (see the *Water Quality Discipline Report* [Herrera 2022a]). Recent water quality trends (2004 through 2014) show reductions in surface total phosphorus and chlorophyll, as well as improvement in water clarity (Secchi depth). The lake is well mixed with little difference in water temperature or dissolved oxygen (DO) through the entire water column. Both surface and bottom DO measurements are well above water quality standards and well within the range required by salmon and other fish. Likewise, although the basin demonstrates water temperatures in excess of riverine water quality standards, from a lake perspective, these water temperatures are low when compared to other lakes in the region. The elimination of brackish water and transition to saltwater have also created habitat for non-native fish species (e.g., bass) and harmful and invasive aquatic invertebrates (such as the New Zealand mud snail). However, recent lake data (2010–2014 and 2019) indicate that Capitol Lake currently has good water quality in terms of physical characteristics important to aquatic life, such as temperature and DO, as well as in terms of chlorophyll concentrations and algae blooms, especially in light of its eutrophic condition. The extensive aquatic plant community remains a concern.

While DO is naturally low in many inlets and embayments in South Puget Sound, the presence of the dam has contributed to poor water quality in the marine portions of the study area, shown by the Budd Inlet modeling study (Ecology 2015b). The study found the largest human-caused contributor to low DO problems in Budd Inlet was loading of nutrients, particularly nitrogen and algae production and decomposition in Budd Inlet and total organic carbon, which primarily originates from Capitol Lake. Decreases in available DO in Budd Inlet can be potentially harmful to salmon and other fish.

The overall density and distribution of aquatic vegetation, including invasive species, became more prevalent as the lake filled in with sediment, limiting habitat quality. Human development along the lake resulted in armored shorelines and decreased the quality and quantity of riparian vegetation, thus reducing the habitat value for native species. In addition, anadromous fish migrating to Puget Sound face physiological challenges from the abrupt transition from freshwater to saltwater. Although the study area still supports a variety of fish, including salmon and steelhead, the geomorphic and ecological conditions of the Lower Deschutes aquatic system are dramatically changed from their historical state, a condition which likely limits some historic fish populations.

4.1.1 Fish Use in Study Area

Many native and nonnative fish species inhabit the freshwater and estuarine habitats of the study area. A variety of fish species utilize the freshwater habitats of the North, Middle, and South Basins, as well as the riverine habitats of the Deschutes River and Percival Creek. Likewise, many fish species use the estuarine habitats of West Bay. Table 4.1 below provides information on the most common of these species (those that are expected to occur in the study area at least occasionally). These are grouped into assemblages (species groups), including anadromous fish (salmonid and non-salmonid), other freshwater fish, and marine fish (Table 4.1). WDFW (Hayes et al. 2008) conducted a thorough review of available data on fish presence and distribution in Capitol Lake and Budd Inlet, based on an extensive search of peer-reviewed and gray literature (information produced by government agencies, academic institutions, and also the for-profit sector that is not typically made available by commercial publishers), and interviews with species and habitat experts. As this work represents the most complete and comprehensive study to-date on this subject, this analysis utilized used similar species groups to characterize fish resources in Capitol Lake.

Table 4.1 Fish Species Potentially Present in the Study Area

Species Group	Species Sub-Group	Species / Status	Scientific Name
Anadromous Fish	**ESA-Listed Species**	Chinook Salmon (FT, SC)[a]	*Oncorhynchus tshawytscha*
		Steelhead Trout (FT)[a]	*O. mykiss*
		Bull Trout (FT)[a]	*Salvelinus confluentus*
	Other Salmonids	Coho Salmon	*O. kisutch*
		Chum Salmon	*O. keta*
		Sea-run Cutthroat Trout	*O. clarkii*
		Sockeye Salmon	*O. nerka*
	Non-salmonids	Starry Flounder	*Platichthys stellatus*
		Three-spined Stickleback	*Gasterosteus aculeatus*
Freshwater Fish (resident)	Native Fish	Resident Cutthroat Trout	*O. clarkii*
		Rainbow Trout	*O. mykiss*
		Peamouth	*Mylocheilus caurinus*
		Northern Pikeminnow	*Ptychocheilus oregonensis*
		Speckled Dace	*Rhinichthys osculus*
		Redside Shiner	*Richardsonius balteatus*
		Largescale Sucker	*Catostomus macrocheilus*
		Prickly Sculpin	*Cottus asper*
		Riffle Sculpin	*Cottus gulosus*
		Western Brook Lamprey	*Lampetra richardsoni*
		Olympic Mudminnow (SS)	*Novumbra hubbsi*
	Exotic/non-native Fish	Common Carp	*Cyprinus carpio*
		Brown Bullhead (E)	*Ameiurus nebulosus*
		Smallmouth Bass (E)	*Micropterus dolomieu*
		Largemouth Bass (E)	*Micropterus salmoides*
		Yellow Perch (E)	*Perca falvescens*
Marine Fish		Pacific Sand Lance	*Ammodytes hexapterus*
		Shiner Perch	*Cymatogaster aggregata*
		Surf Smelt	*Hypomesus pretiosus*
		Arrow Goby	*Clevelandia ios*
		Pile Perch	*Rhacochilus vacca*

Species Group	Species Sub-Group	Species / Status	Scientific Name
		Bay Pipefish	*Syngnathus griseolineatus*
		Staghorn Sculpin	*Leptocottus armatus*
		Tidepool Sculpin	*Oligocottus maculosus*
		Sand Sole	*Psettichthys melanostictus*
		Speckled Sand Dab	*Citharichthys stigmaeus*

FT= Federally Threatened, SC = State Candidate, SS = State Sensitive, E = Exotic.

[a] No naturally reproducing native populations of Chinook salmon, steelhead, or bull trout are present within the Deschutes River Basin or Percival Creek, although use of the study area by these species may occur. Chinook salmon from the Tumwater Falls Hatchery are not listed under ESA.

Sources: Hayes et al. (2008), USFWS (2009), WDFW (2020d), and Freeman (pers. comm. 2022).

4.1.1.1 Anadromous Fish

Nine anadromous fish species, including seven salmonid species, may occur in the Capitol Lake Basin or its immediate vicinity at different stages of their life history. The timing of salmonid presence in the Capitol Lake Basin is presented in Table 4.2. Two non-salmonids (three-spined stickleback and starry flounder) may also occur in the lake.

These species, particularly the salmon, have significant cultural and economic value to area tribes. Capitol Lake is located within the traditional territory of the Southern Coast Salish cultural group, which includes but is not limited to the Steh-chass, Nusehchatl, Squaxin, and Nisqually, and provide fish harvesting opportunities for some tribes (see the *Cultural Resources Discipline Report* for more information [ESA and NW Vernacular 2022]).

Adult anadromous salmonids returning to the Capitol Lake Basin can continue their upstream migration by moving into the Deschutes River, which flows into the lake from the south, or Percival Creek, which enters the Middle Basin from the west. When draining into the lake, Percival Creek drains into a cove, called Percival Cove, which is partially separated from the rest of the Middle Basin by the Deschutes Parkway SW.

Capitol Lake is a migratory corridor for outmigrating salmonid smolts and returning adult salmonids (Hayes et al. 2008). Some juvenile rearing is assumed to occur in Capitol Lake during the spring outmigration and possibly extending into summer or later (Hayes et al. 2008). Steltzner (2007) reported that hatchery juvenile Chinook salmon released from the Tumwater Falls Hatchery appeared to rear in the lake for 6 to 10 days in the spring. This same residency is assumed for any Chinook salmon produced in Percival Creek. Freshwater fish species in Capitol Lake remain there throughout the year, except for those times when they may move into the lower portions of the Deschutes River or Percival Creek.

Table 4.2 Life History and Timing of Salmon Species in Capitol Lake

Salmon Species and Run	Life Stage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Coho Salmon	Adult River Entry																		■	■	■	■			
	Juvenile Rearing and Outmigration					■	■	■	■	■	■	■	■												
Fall Chum Salmon	Adult River Entry	■																					■	■	■
	Juvenile Rearing and Outmigration				■	■	■	■	■	■															
Fall Chinook Salmon (hatchery origin)	Adult River Entry														■	■	■	■	■	■	■				
	Juvenile Rearing and Outmigration					■	■	■	■	■	■	■													
Winter Steelhead	Adult River Entry	■	■	■	■	■																■	■	■	■
	Juvenile Rearing and Outmigration					■	■	■	■	■	■	■	■	■	■										
Sea-run Coastal Cutthroat Trout	Adult River Entry	■	■	■	■	■	■														■	■	■	■	■
	Kelts (adults) Outmigration						■	■																	
	Juvenile Rearing and Outmigration								■	■	■	■													
Bull Trout	Adult/Sub-adult Foraging							■	■	■	■	■	■												
	Juvenile Rearing and Outmigration																								

■ present

Sources: Williams et al. (1975), WDFW and WWTIT (1994), WDFW (2000), TCDLE (2004).

Historically, anadromous salmonids could only access the Deschutes River to the upstream margin of the approximately 2-mile-long estuary because of the natural barrier, Tumwater Falls, immediately upstream of the estuary. In 1954, a fish ladder was constructed that allowed anadromous salmonids to access habitats in the Deschutes River upstream of Tumwater Falls.

WDFW operates a hatchery at Tumwater Falls with a production goal is 3.8 million juvenile Chinook salmon per year that are released into the Deschutes River at the hatchery (WDFW 2020a). An adult collection pond at the top of the fish ladder system is used to capture hatchery-origin Chinook salmon for broodstock collection by the WDFW Tumwater Falls Hatchery. It also allows WDFW to control and count the number of adult salmonids allowed to migrate farther upstream in the Deschutes River. WDFW fish counts at the fishway and hatchery are the basis of the salmon numbers provided below.

As summarized by Hayes et al. (2008), hatchery Chinook salmon and coho salmon were planted in the upper Deschutes River (above the falls) and Percival Creek at various times since 1953. Steelhead have also been planted in the upper Deschutes River. Such releases of juvenile salmonids to the Upper Deschutes River have not occurred in recent years, except for limited releases of coho salmon. Hatchery-origin fall Chinook salmon and some coho salmon were reared by WDFW in net-pens and open water in Percival Cove from the 1960s until ending in 2007 (Hayes et al. 2008).

ESA-Listed Anadromous Salmonids

Chinook Salmon

Chinook salmon are present throughout the study area, including the Capitol Lake Basin and West Bay. The Chinook salmon returning to the Deschutes River and Percival Creek are fall-run Chinook salmon of hatchery origin (Haring and Konovsky 1999). They are not part of the native PS population and therefore not listed as threatened.

The number of Chinook salmon adults returning to the Tumwater Falls Hatchery each year between 2013 and 2018 is presented in Table 4.3 (WDFW 2020b). While the vast majority are used for broodstock, a small number of Chinook salmon have been released upstream of the facility. Since 2019, no Chinook salmon adults are allowed upstream of the hatchery in order to avoid Chinook salmon interactions with native coho salmon spawning (Pilon, pers. comm.). Between 2013 and 2018, some males and jacks were released upstream, but no females were released (Topping, pers. comm.). This was to prevent hatchery Chinook salmon spawning, while providing a recreational fishing opportunity and adding marine-derived nutrients to the Deschutes River watershed.

Table 4.3 Annual Number of Chinook Salmon Collected at Tumwater Falls Hatchery

Return Year	Adults	Jacks	Total
2013	10,157	572	10,729
2014	2,946	138	3,084
2015	3,747	1,265	5,012
2016	13,188	702	13,890
2017	30,081	3,806	33,887
2018	11,467	945	12,412

Adult fall Chinook salmon returning to spawn first appear at the 5th Avenue Dam fish ladder in late July and continue upstream migrations through October (Williams et al. 1975). Spawning generally occurs between late September through October (SPSSRG 2005). The fall-run Chinook salmon are considered "ocean type," such that they typically outmigrate to saltwater as smolts during their first spring or summer. Chinook salmon are the most dependent salmon species on estuaries as they outmigrate from rivers as juveniles (Healey 1982). In natural estuaries, the gradual transition from freshwater to saltwater supports the physiological transition the juvenile salmon must undergo (Fresh 2006). While rearing in estuaries, juvenile salmon utilize tidal channels, tideflats, and vegetated salt marsh habitats that provide abundant prey resources and support rapid growth (Simenstad et al. 1982).

Steelhead

Very low numbers of Steelhead are thought to return to the Deschutes River and Percival Creek (Pilon pers. comm.). The returning steelhead are winter-run steelhead and are a distinct non-native stock (Haring and Konovsky 1999). They spawn naturally in the Deschutes River upstream of Tumwater Falls. Adult steelhead return to rivers between November and mid-March, and spawn timing is from early January to early April (WDFW and WWTIT 1994). Steelhead typically remain in freshwater for two or three years before migrating out to the ocean (Thurston Conservation District Lead Entity 2005).

Data are not available on the number of steelhead returning to the Deschutes River because WDFW does not trap fish during the time of the year (December through February) that the adults would be returning to river. Past efforts by WDFW to trap returning steelhead in the early 2000s did not capture any. Based on the absence of steelhead during those sampling efforts, WDFW assumes that steelhead numbers returning to the Deschutes River are very low (Pilon pers. comm.).

Bull Trout

Bull trout do not reproduce in the freshwater portions of the study area due to the presence of the fish barrier at Tumwater Falls, and a lack of complex habitat, cold, clean water, and suitable spawning gravel in this area. However, bull trout may enter Capitol Lake on feeding forays, especially when hatchery-produced or naturally spawned juvenile salmon are outmigrating. Foraging or migrating adult bull trout may also be in the saltwater habitats of Budd Inlet, including West Bay. Bull trout exhibit multiple migratory strategies, commonly occupy patchy distributions, and are associated with cool water and complex habitats.

Other (non-ESA Listed) Anadromous Salmonids

Coho Salmon

Coho salmon are present throughout the study area, including the Capitol Lake Basin and West Bay. Coho salmon spawn and rear in both the Deschutes River and Percival Creek (WDFW and NWIFC 2020). Coho salmon in the Deschutes River are of non-native origin. The river was historically inaccessible to coho salmon due to the natural barrier at Tumwater Falls. With the installation of a series of fish ladders that allow fish past Tumwater Falls and the release of hatchery-origin coho salmon, a population was established in the Deschutes. Hatchery releases have occurred intermittently since the late 1940s, with limited releases continuing.

Historically, Percival Creek likely supported a native coho salmon run. Although little actual data exist, anecdotal information, such as the presence of a fly fishery in the historic Deschutes estuary (prior to dam installation), indicates that native coho salmon utilized Percival Creek for spawning and rearing. However, various stocks of coho salmon have been planted in Percival Creek since 1953 (Hayes et al. 2008) and there are little data on the current stock origin and status of the species in Percival Creek. There is also little information on the total abundance or the number of spawners for coho salmon in Percival Creek. In 1991, a fish survey utilizing electroshocking techniques was conducted in the canyon portion of the Percival Creek (Thurston County 1993), which established the presence of approximately 17 juvenile coho salmon distributed at four locations. Prior to 1996, a major fish barrier was present in lower East Fork Percival Creek (river mile 1.2) in the form of a high-gradient culvert under Mottman Road, which limited upstream access of coho salmon. However, in 1996 the culvert was retrofitted, which improved fish passage but did not restore full fish passage (WDFW 2022a). Currently, coho salmon presence in Percival Creek includes almost the entire lengths of Black Lake Ditch and the East Fork mainstem (NWIFC 2020b).

Coho salmon typically migrate to marine waters after spending 18 months in freshwater (Weitkamp et al. 1995). Adults return to the rivers in mid-September to mid-November and spawn between late October and early January (WDFW and WWTIT 1994). Fry emerge from the gravel in late winter and early spring. After 1 year rearing in the river, young coho salmon outmigrate from the river in the spring. After leaving Capitol Lake and entering saltwater, coho salmon migrate out of Puget Sound to the Pacific Ocean. Adult coho salmon return in late summer and early fall of the following year.

Due to a consistent 3-year life cycle among coho salmon (1.5 years in freshwater and 1.5 years in saltwater), there are generally three separate brood year lineages. Every 3 years, the strongest brood year lineage returns and tends to have more returning coho than the 2 weaker brood year lineages. In the strongest of the three brood year lineages returning to the Deschutes River, the annual number of adults has ranged between 800 and 2,450 since 1991. However, the two other brood year lineages have had much lower numbers, including 100 or fewer adult coho salmon returning in 9 of the last 14 years of returns for those lineages (Topping, pers. comm.)

Chum Salmon

Low numbers of Chum salmon are present throughout the study area, including the Capitol Lake Basin and West Bay. Chum salmon are documented as spawning in Percival Creek (Hayes et al. 2008). These are fall Chum salmon (WDFW and NWIFC 2020) that are assumed to be strays from larger Chum salmon runs elsewhere in South Puget Sound (Hayes et al. 2008). Haring and Konovsky (1999) reported no Chum salmon in the Deschutes River.

When young, Chum salmon spend little time in freshwater. When fry emerge from the gravel, they immediately begin their migration downstream to estuarine/nearshore areas (Salo 1991). Outmigrating fry either rear for weeks in natal estuarine habitats or pass directly through into Puget Sound (Fresh 2006). Based on the timing of the nearby Eld Inlet fall Chum salmon stock, they return to rivers and spawn between mid-November and mid-January (WDFW and WWTIT 1994).

Sockeye Salmon

There is no sockeye salmon stock documented with distributions extending into Capitol Lake, Deschutes River, or Percival Creek (WDFW and WWTIT 1994). Haring and Konovsky (1999) reported isolated observations of sockeye salmon spawning in Percival Creek and annual observations of 10 or fewer adult sockeye salmon returning to the Deschutes River. Between 2008 and 2018, 15 total sockeye salmon were released upstream of Tumwater Falls with no more than five in any single year Topping (pers. comm.).

Sea-Run Coastal Cutthroat Trout

Sea-run coastal cutthroat trout are present throughout the study area, including the Capitol Lake Basin and West Bay. Coastal cutthroat trout are documented as having distributions that include the Deschutes River and Percival Creek. There is no information on the abundance of the population.

Sea-run coastal cutthroat trout typically spend between 2 and 4 years in freshwater before migrating to marine waters (Giger 1972, Lowery 1975). Coastal cutthroat trout outmigrate in the spring, with the fish tending to rear extensively in shallow intertidal areas, preying on forage fish (Mason Conservation District 2004). After feeding in saltwater and estuaries for several months, most anadromous coastal cutthroat trout return to freshwater to overwinter and spawn, although sexual maturity of returning fish varies by geography and sex (Fuss 1982, Tipping 1981). Like steelhead, anadromous coastal cutthroat trout are iteroparous and adults may spawn in multiple years (Trotter 1989). Sea-run coastal cutthroat trout enter rivers as adults between mid-October and the end of March, with spawning occurring between January and March (WDFW 2000).

Anadromous Non-Salmonids

Two species of anadromous non-salmonids occur in Capitol Lake: three-spined stickleback and starry flounder. Three-spined stickleback have both anadromous and resident life history forms. Three-spined stickleback have been captured in sampling in lower Budd Inlet by Steltzner (2003) and are presumed to be the anadromous form (Hayes et al. 2008). It is not known how much of the current population in

Capitol Lake is the anadromous form (Hayes et al. 2008). Hayes et al. (2008) cites several sources indicating that three-spined stickleback comprise an overwhelming majority of the fish population in Capitol Lake. The anadromous form spends most of its adult life in the marine environment feeding on plankton and returns to freshwater to breed (USGS 2020). Breeding occurs annually from late April to July in ponds, rivers, lakes, drainage canals, marshes, sloughs, tidal creeks, and sublittoral zones of the sea (Bell and Foster 1994, Mattern et al. 2007). Three-spined stickleback do not die after spawning and can breed more than once (Hayes et al. 2008). The eggs hatch 5 to 10 days after fertilization (Bell and Foster 1994). Individuals reach sexual maturity between 1 and 2 years of age. The average lifespan of this species is ranges is only about 1 to 3 years (Wootton 1976).

Starry flounder were documented in Capitol Lake during a drawdown in 1996 but were not found in 1997 (Hayes et al. 2008). Starry flounder are a bottom-dwelling flatfish. Starry flounder spawn at the freshwater interface in upper estuaries, often at or near the first riffles leading into estuaries (Orcutt 1950, Horton 1989). Starry flounder do not die after spawning and can breed more than once (Hayes et al. 2008). Hayes et al. (2008) notes that a lack of data prevents understanding the status of starry flounder in Capitol Lake.

4.1.1.2 Freshwater Fish

As noted by Hayes et al. (2008), limited information is available on the fish community of Capitol Lake. The following discussion of Capitol Lake's freshwater fish community is based on information from Hayes et al. (2008), unless otherwise referenced. It is known from the historic drawdowns of the lake that it supports several thousands of fish.

Table 4.4 lists the documented freshwater species of Capitol Lake, notes whether they are native or non-native, and describes their ecological role based on Wydoski and Whitney (2003). The ecological role is described as it relates to habitat use and potential for competition and predation with anadromous salmonids in the study area. Note that several species of both native and non-native fish have an ecological role that involves either predation on, or feeding competition with, salmonid species.

The abundance in Capitol Lake of the species listed in Table 4.4 varies and in most cases is unknown. For example, Olympic mudminnows (*Novumbra hubbsi*) are documented in the lower portion of the Deschutes River watershed (Mongillo and Hallock 1999), and two Olympic mudminnows were sampled among the 320 fish collected in isolated pools in Percival Cove using electrofishing during the 1997 lake drawdown (Entranco 1997). Olympic mudminnows are typically found in slow-moving streams, wetlands, and ponds (Mongillo and Hallock 1999). In these habitats, they require a muddy bottom, little or no water flow, and abundant aquatic vegetation (Mongillo and Hallock 1999). However, Hayes et al. (2008) did not include Olympic mudminnow in a Capitol Lake effects analysis noting that "Capitol Lake is not preferred habitat."

Table 4.4 Freshwater Fish Species Potentially Present in the Study Area

Species	Origin	Lake Habitats Occupied	Ecological Role
Three-spined Stickleback	native	littoral, limnetic, and benthic	Numerous, substrate-oriented, often near aquatic vegetation, provide prey for larger fish.
Coastal Cutthroat Trout	native	littoral and limnetic	Resident life history form competes with other salmonids for prey when young and is a major predator when larger.
Rainbow Trout	non-native	littoral and limnetic	Resident life history that is the same species as steelhead. Overlapping habitat with other salmonids; consume similar prey. Potential competitor and predator of young anadromous salmonids.
Peamouth	native	littoral	Occupies shallow benthic habitats in lakes and streams. Potential competitor of young anadromous salmonids.
Northern Pikeminnow	native	littoral and limnetic	Occupies lakes and slow-moving habitats in streams. Major fish predator that occupies salmonid fish habitat.
Speckled Dace	native	littoral and benthic	Occupies benthic habitats. Generally, found in shallow water less than 3 feet deep. Some prey overlap with young anadromous salmonids.
Redside Shiner	native	littoral, benthic, and sometimes limnetic	Uses shallow and deep habitats. Some prey overlap with young anadromous salmonids.
Largescale Sucker	native	littoral and benthic, except for brief period of limnetic	Occupies benthic habitats of lakes and streams. Young largescale sucker have some diet overlap with young anadromous salmonids.
Olympic mudminnow	native	littoral	Occupies freshwater habitats with little to no flow, muddy substrates, and abundant aquatic vegetation.
Prickly Sculpin	native	littoral and benthic	Occupies shallow and deep benthic habitats. Potential competitor and predator of young anadromous salmonids.
Riffle Sculpin	native	littoral and benthic	Occupies shallow benthic habitat, generally sand or gravel. Potential competitor of young anadromous salmonids.

Species	Origin	Lake Habitats Occupied	Ecological Role
Western Brook Lamprey	native	littoral and benthic	Larval life stage occupies silty benthic habitats in quiet backwater areas. Juveniles and adults occupy gravel stream beds. Species is non-parasitic and does not harm other fish.
Common Carp	non-native	littoral and benthic	Occupies depths up to 100 feet in lakes and streams. Young carp are a potential competitor of young anadromous salmonids.
Brown Bullhead	non-native	littoral and benthic	Competitor with young salmonids for similar prey.
Smallmouth Bass	non-native	littoral and limnetic	Major fish predator that occupies salmonid habitat, resulting in some prey competition.
Largemouth Bass	non-native	littoral and limnetic	Major fish predator that occupies shoreline habitat. Young bass compete with young salmonids for some prey.
Yellow Perch	non-native	littoral and limnetic	Consumes similar prey as young salmonids. Potential competitor and predator of young anadromous salmonids.

4.1.1.3 Marine Fish

Table 4.5 lists the documented marine species of West Bay, notes whether they are native or non-native, and describes their ecological role based on Hayes et al. (2008). It should be noted that many more marine species inhabit Puget Sound than are listed below. For example, the marine waters of Puget Sound are home to dozens of species of bottomfish, including dogfish, skates, rockfish (at least 14 species), greenlings, sculpins, surfperches, and flatfish (sandab, halibut, sole, and flounder). While any of these species may occasionally be present the waters of West Bay, this analysis focuses on those marine fish that have been documented in the study area and our likely to occur (Hayes et al. 2008). The ecological role of these species is described in Table 4.5 as it relates to habitat use and potential for interactions with anadromous salmonids in the study area.

Table 4.5 Marine Fish Present in Study Area and Lower Budd Inlet

Species	Origin	Ecological Role
Pacific Sand Lance	native	Beach-spawning fish that deposits eggs on sand in mid and upper intertidal zone. Schooling species. Important prey species in food web, including for salmonids.
Surf Smelt	native	Beach-spawning fish that deposits eggs on pea gravel and coarse sand in upper intertidal zone. Schooling species. Important prey species in food web, including for salmonids.

Species	Origin	Ecological Role
Shiner Perch	native	Schooling species. Common in nearshore, including fish surveys of Budd Inlet. Diet overlaps with young anadromous salmonids.
Pile Perch	native	Common in estuaries around piling and other underwater structures.
Bay Pipefish	native	Occupies shallow subtidal habitats. Diet includes plankton and small crustaceans.
Arrow Goby	native	Bottom-dwelling fish known to use burrows created by shellfish. Diet overlaps with young anadromous salmonids.
Pacific Staghorn Sculpin	native	Common in estuaries. Occupies benthic habitats. Larger sculpins are a potential predator of young anadromous salmonids.
Tidepool Sculpin	native	Small intertidal fish. Diet overlaps with young anadromous salmonids.
Sand Sole	native	Medium-sized bottom-dwelling flatfish. Larger soles are a potential predator of young anadromous salmonids.
Speckled Sand Dab	native	Medium-sized bottom-dwelling flatfish. Diet overlaps with young anadromous salmonids.

4.1.2 Listed or Sensitive Fish Species and Habitats

Puget Sound Chinook salmon are listed as threatened under the ESA (NMFS 1999); however, this applies to native populations, which are not present in the Deschutes River or Percival Creek watersheds (Pilon, pers. comm.; Dickison, pers. comm.). The Capitol Lake Basin and freshwaters flowing into it are not designated as critical habitat. The estuarine waters of Budd Inlet are designated as critical habitat.

Puget Sound steelhead are also listed as threatened under the ESA (NMFS 2007). Capitol Lake and the Deschutes River are designated as critical habitat for steelhead, although the steelhead returning to the Deschutes River are a distinct non-native stock (Haring and Konovsky 1999).

Bull trout, listed as federally threatened (USFWS 1999), may occasionally be present in the marine waters of West Bay, but there is no bull trout habitat in Capitol Lake or its tributaries. No designated critical habitat for bull trout is present in the study area (USFWS 2005).

Two species of ESA-listed rockfish occur in Puget Sound. The bocaccio rockfish (*Sebastes paucispinis*) is listed as endangered while the yelloweye rockfish (*Sebastes ruberrimus*) is listed as threatened under the ESA. Although larval and juvenile rockfish could occasionally be present in the study area, as they are widely dispersed by surface water currents, adults and juvenile rockfish are not likely to occur in the relatively shallow waters of West Bay, where kelp beds and underwater cliff habitats deeper than 45 feet (both preferred habitat) (USACE 2012) are generally lacking. As the study area does not represent high quality habitat and no rockfish have been observed in Budd Inlet (Hayes et al. 2008), these two species are not considered further in this document.

4.1.3 Fish Habitat Conditions in the Study Area

The study area includes riverine, lacustrine, and estuarine fish habitat features. Each of these habitats, described in greater detail below, provides unique ecological functions that support a variety of freshwater and marine fish.

4.1.3.1 Deschutes River Basin

The study area includes the Deschutes River, which is the largest drainage system within Water Resource Inventory Area (WRIA) 14, the Deschutes River watershed. The Deschutes River drains a total of approximately 166 square miles, representing approximately 84% of the WRIA (Haring and Konovsky 1999). The headwaters of the Deschutes River are located in the Mt. Baker-Snoqualmie National Forest, within Lewis County, and the lower portion of the river flows through the City of Tumwater and the City of Olympia, draining into Capitol Lake and eventually into Budd Inlet.

The Deschutes River basin includes commercial forestry in the upper basin and agriculture and rural residential in the middle of the watershed. Urban land uses in the lower watershed include portions of the cities of Tumwater and Olympia. Riparian cover is limited within much of the study area, reflecting current land uses, with riparian conditions including a combination of high-density urban land use, mixed coniferous and deciduous forest, and maintained grass areas. However, high-quality riparian shorelines are located along the east shore of the Middle Basin, the east and south shore of the South Basin, and the west shore of Percival Cove. The City of Olympia designates these priority habitat areas as "Important Riparian Areas." In addition, the forested hillside of Capitol Lake is the largest contiguous habitat unit within the City of Olympia or the City of Tumwater (TRPC 2008).

Flows in the Deschutes River (measured at the E Street Bridge in Tumwater) range from 1 to 243 cfs, based on data from 1945 through 2019 (Moffatt & Nichol 2022), with a mean of 11.98 cfs and a 50% exceedance flow of 7.53 cfs.

4.1.3.2 Capitol Lake

Historically, the Deschutes Estuary and the area that is now Capitol Lake was a part of Budd Inlet, consisted of intertidal tideflats that typically form at the mouths of estuaries. The study area has been substantially altered in the last 100 years, including construction of BNSF railroad tracks across the mouth of the Deschutes River in 1929, separating what is now the North Basin and Middle Basin and a railway installed at the mouth of Percival Creek, creating Percival Cove (TRPC 2008). Around 1942, the 5th Avenue Bridge was constructed using earthen fill and the 5th Avenue Dam and tide gates were installed in 1951, blocking tidal flow and creating the freshwater habitat of Capitol Lake and a reflecting pool for the state capitol building. Additional fill in the lake was introduced in 1956, when the I-5 bridge was constructed, which separated the Middle Basin and South Basin of the lake. More in-water fill was placed in the North Basin to construct Deschutes Parkway and Marathon Park in the 1970s, and additional armoring was installed in 1999 for the construction of Heritage Park (Herrera 2005). Overall, the North Basin of Capitol Lake's shoreline is highly modified, including an armored bulkhead along Heritage Park on the east side and riprap supporting Deschutes Parkway on the west side, which extends along the western shoreline of the Middle Basin. In contrast, the shorelines in the Middle and South Basins are more natural, including wetlands and riparian vegetation at the basin margins.

The existing habitat in Capitol Lake consists of a shallow lake environment with low to moderate densities of aquatic macrophytes, including invasive species, covering the lake environment. The restriction of water flow created several environmental issues in Capitol Lake. Water exchange in the Capitol Lake Basin (currently exchanging every 14 days) is limited compared to historical estuary conditions, with water exchange rates varying from 0.2 day (high winter flows) to as slow as 9 days (summer low flows) (Roberts et al. 2012).

There are now three basins in Capitol Lake (the North Basin, Middle Basin, and South Basin), with the Deschutes River flowing north through all three basins to West Bay (Figure 1.1). Capitol Lake is 1.6 miles long, with 5.3 miles of shoreline. The mean lake depth is 9 feet, with a maximum depth of 20 feet and a lake volume of approximately 2,400 acre-feet. Historically, the Deschutes River discharged directly into Budd Inlet.

Drainage from Percival Creek and Percival Cove flows into the Middle Basin under the Deschutes Parkway. The size of each basin (North, Middle, and South) and Percival Cove is 96 acres, 120 acres, 30 acres, and 16 acres, respectively, and the total area of Capitol Lake Basin is about 260 acres. Normal summer lake level is 8.65 feet (NAVD88), while winter lake levels are approximately 1.0 foot higher at 9.61 feet (NAVD88) (Moffatt & Nichol 2020).

The construction of the 5th Avenue Dam has resulted in sediment deposition in Capitol Lake from upstream in the Deschutes River and Percival Creek, filling the lake and slowly and promoting the development of freshwater wetland habitat, especially along the margins of the basins. The largest deposition thickness of over 13 feet occurred in the South Basin due to channel migration, while most of the Middle Basin had deposits of approximately 7 feet of sediment, with some areas showing nearly 10 feet of deposition (Moffatt & Nichol 2022). In the North Basin, the original channel was filled with 3 to 6 feet of sediment, while most of the North Basin had a deposition amount between 1.5 and 3 feet. The total annual sedimentation volume dropped 32% from 21,647 cubic yards (CY) to 13,994 CY based on the 1949-2013 and 2013-2020 data (Moffatt & Nichol 2022).

A streambank erosion survey was conducted during 1982 and 1983 and determined that the majority of eroding material from the upstream consisted of fine sands, silts, and clays that were transported along the river and deposited in Capitol Lake (TRPC 2008). This is reflected by moderate to high (11% to 20%) percent fines in spawning gravels in the river mainstem and several tributaries (Schuett-Hames and Flores 1994). Fine sediments within the river were found to originate from a variety of sources, including: erosion of glacial terrace banks; erosion and landslide occurrences due to record flood events; bank erosion in tributaries; increased levels of shoreline armoring that may contribute to localized scour; and other anthropogenic factors associated with shoreline modification and infrastructure that may lead to runoff, landslides, and downstream sediment input (Raines 2007).

Sediment data collected in Capitol Lake indicate that grain size varies from sand to silt, with the eastern and western sides of the North Basin characterized by fine sediment deposits, while coarser sediments are observed near the dam. Coarse sandy sediments are observed in the Middle Basin near the BNSF railroad trestle between the Middle and North Basins. The estimated annual sediment load to Capitol Lake is between 29,000 and 55,000 CY/year (1952–1996), while for Percival Creek the annual sediment load is 1,400 to 6,000 CY/year, resulting in increasing lake bed elevations of approximately 3 feet every 25 years in Capitol Lake (Moffatt & Nichol 2022).

To address sedimentation, two sediment traps were constructed in 1978. The traps were built by removing 200,000 CY of sediment in the South Basin and the Middle Basin north of the I-5 Bridge. However, the South Basin trap did not function well and was abandoned. The only maintenance dredging of the Middle Basin trap since 1978 occurred in 1987, when 57,000 CY of sediment were dredged, with an accumulation rate of 6,300 CY/yr increase in thickness in this trap (Entranco 1990). In 2019, some areas in the lake were dredged during an oil spill cleanup by Washington State Department of Ecology (Ecology), with a dredged sediment thickness in these areas ranging from 6 inches to 4 feet.

Water quality is a fundamental determinant of habitat conditions for fish and affects their survival, distribution, growth, behavior, and susceptibility to disease. Comparing water quality data from 2010 through 2014 with state surface water quality standards indicates that the lake occasionally does not meet standards for temperature, dissolved oxygen, total dissolved gas, and pH. The water quality trend analysis presented in the *Water Quality Discipline Report* (Herrera 2022a) indicates that Capitol Lake exhibited improving water quality from 2004 to 2014 based on significant improvement in temperature, total phosphorous, chlorophyll a, Secchi depth, and fecal coliform bacteria. These trends generally appear to be most evident in the fall and spring. The improvements summarized indicate that watershed improvement activities carried out over the past 25 years, including removal of the brewery discharge, have been effective at improving overall water quality in the lower Deschutes River and Capitol Lake.

Ecology has released a draft water quality improvement plan, known as Total Maximum Daily Loads (TMDLs) for dissolved oxygen (DO) in Budd Inlet (Ecology 2022). Ecology has found that the 5th Avenue Dam causes the largest negative impact on DO in Budd Inlet of any activity evaluated due to the dam's combined effects of changing circulation as well as nitrogen and carbon loads.

Aquatic life is threatened by high levels of phosphorus, which tends to promote the growth of algae and aquatic weeds (such as the noxious weed, Eurasian watermilfoil) which in turn reduces the DO content of the water (Thurston County 2006). High total phosphorus and nitrate and nitrite concentrations above the regional reference condition were recorded over multiple years (Thurston County 2017). However, phosphorus levels have been decreasing in recent years. For more detail on water quality in the study area, see the *Water Quality Discipline Report* (Herrera 2022a).

Anadromous salmonids undergo a physiological transition as outmigrating juveniles prepare to move from a freshwater environment to a saltwater environment. In natural estuary settings, the transition from freshwater to saltwater is gradual and occurs over a distance related to the freshwater inflows from the river's watershed and the topographic and bathymetric configuration of the estuary relative to tides. The gradual increase in salinity provides juvenile salmon with a physiological transition zone to gradually acclimate to saltwater (Simenstad et al. 1992, Thorpe 1994). In Capitol Lake, the transition is abbreviated as outmigrating salmon move from the largely freshwater habitats of Capitol Lake to the saltwater of Budd Inlet in a short distance near the 5th Avenue Dam and tide gate. Such an abrupt transition is assumed to provide physiological stress to the outmigrating salmon and potentially reduces their fitness and overall survival in the marine environment (Chittenden et al. 2008).

Outmigrating salmon in the lake also encounter several structures that span the lake, with both in-water and overwater components. These are the existing railroad bridge spanning approximately 210 feet over the North Basin and the I-5 crossing spanning approximately 200 feet over the South Basin. These structures represent the narrower points in the basin and also have bridge piers/piling bents in-water, preferred habitat for freshwater predators on salmonids, including bass (*Micropterus* spp.) and northern pikeminnow (*Ptychocheilus oregonensis*). Although the crossings may contribute to some increased predation on salmonids, the structures also maintain substantial open water segments between bents/piers that provide a more protected route for migrating salmonids.

Riparian conditions in Capitol Lake vary substantially within the three basins. In the North Basin, the Arc of Statehood path and adjacent roadways are so close to the shore that there is only a narrow strip (generally 40 to 50 feet) of riparian vegetation, which consists primarily of shrubs and grass (including landscaped and maintained grasses). Although some trees are present, these are generally ornamental and native deciduous trees, with few to no tall trees (over 100 feet) or coniferous trees. Such conditions provide relatively few riparian functions compared to what occurred here before the lake was created. Conditions on the west bank of the Middle Basin are similar; however, this area contains larger deciduous and some coniferous trees. In addition, the vast majority of the east bank of the Middle Basin provides a 300-foot-wide riparian zone, consisting of mature mixed forest, including overhanging vegetation. The South Basin also has somewhat natural riparian conditions, consisting of emergent and scrub-shrub vegetation as well as some patches of deciduous trees.

Salmonids are cold water species who are sensitive to warmer water temperatures. Many of the freshwater fish of Capitol Lake are warmwater species who prefer warmer water temperatures, which can be exacerbated by shallow lake basins and the lack of natural flushing due to the presence of the 5th Avenue Dam. In addition to the invasive and non-native fish populations listed in Table 4.4, Capitol Lake also contains well-documented populations of plants, invertebrates, amphibians, waterfowl, and aquatic mammal species. Aquatic invasive plants found in Capitol Lake and the surrounding waterbodies include purple loosestrife (*Lythrum salicaria*) and Eurasian watermilfoil (*Myriophyllum spicatum*), which are classified as high priority for control (WISC 2020). Eurasian watermilfoil has the greatest potential to negatively affect fish habitat. Eurasian watermilfoil spreads rapidly and commonly forms dense, thick mats. The mats reduce sunlight and oxygen in underlying waters, thus degrading water quality, outcompeting native vegetation, decreasing habitat quality for native fish species, and inhibiting recreational activities. Watermilfoil treatment and control activities have occurred in Capitol Lake since 2004; however, the species continues to spread, reaching all three lake basins and Percival Cove (see the *Aquatic Invasive Species Discipline Report* for details (Herrera 2022b).

Watermilfoil often forms a floating canopy that shades native aquatic plants and reduces their growth (Frodge et al. 1995). Watermilfoil contributes to phosphorus loading in the lake sediments through its release of phosphorus during decomposition. Dense communities can reduce DO to below 5 parts per million (less than the minimum requirements for salmonids) through oxygen consumption during respiration at night (WDFW 2001). In addition, the decomposition of dead plant material increases the biological oxygen demand, further reducing DO and pH. In summary, dense communities of aquatic vegetation, or floating mats of detached plants, can adversely affect localized water quality conditions. Under extreme conditions, these situations can become anoxic.

In addition, excessive accumulation and decomposition of organic material can transform areas of natural sand or gravel substrate to fine silt and mud, with substantial accumulations of organic material from the decomposition of watermilfoil and other aquatic vegetation. The dense vegetation reduces the currents and wave energy in these areas, encouraging the accumulation of fine sediment material.

The presence of Eurasian watermilfoil can also affect the distribution and habitat usage of salmonids. Tabor et al. (2006) found that the presence of Eurasian watermilfoil in Lake Washington appeared to cause juvenile Chinook salmon to be farther offshore in deeper water, where they be more susceptible to bass predation. Most bass congregate near docks and other artificial structures (Celedonia et al. 2008b), but distribution shifts to deeper littoral zones in late summer were theorized to reflect watermilfoil growth under and adjacent to these structures.

In addition to invasive plants, one of the primary invasive organisms of concern is the New Zealand mudsnail, a prohibited invasive species in Washington. This species reproduces both sexually and asexually, has broad environmental tolerances, has no naturel predators in Washington, and can survive outside the aquatic environment for long time periods, allowing large densities to form (see the *Aquatic Invasive Species Discipline Report* for details). The New Zealand mudsnail consumes high amounts of periphyton and can outcompete native fish species for natural resources, resulting in reduced body weight and health of native salmonids (Vinson and Baker 2008, Alonso and Castro-Díez 2012). First observed in Capitol Lake in 2009, the snail has spread to the North Basin, Middle Basin, South Basin, and the Deschutes River. Management approaches have been applied to control the snail, including draining the lake and exposing the snails to freezing and backflushing the lake with saltwater, both methods that achieved partial success. Furthermore, the lake has been closed to recreation as a management measure to prevent the spread of the snail to other waterbodies.

5th Avenue Dam Fish Passage Structure

The 5th Avenue roadway is located atop the 5th Avenue Dam; the section of roadway atop the spillway is referred to as the 5th Avenue Bridge. The spillway includes two flood control discharge channels and a fishway channel with timber baffles that form a fish ladder designed to provide water depth, velocity, and jump conditions that facilitate fish passage between the lake and the marine waters of Budd Inlet.

The fishway meets WDFW fish passage criteria and is considered 100% passable following improvements made in 2002 (WDFW Site ID: 970005). Previously, the tide gate and fishway could potentially delay the upstream migration of adult salmonids during low tides (Haring and Konovsky 1999), also affecting the movement of smaller fish (i.e., less than 6 inches long). This occurred when the lower lake levels in winter and the relatively high elevation of the fish ladder limited movement into and out of the lake to times when the tide gate is open and flow conditions were sufficient to allow these relatively weak-swimming fish to move freely. Currently, movement of juveniles may still be somewhat impaired under certain tidal and streamflow conditions per information from the Squaxin Island Tribe (Steltzner, 2021 pers comm).

Currently, the exchange of water when the tide gate is open creates the potential to entrain fish and move them into areas that are not suitable for them (i.e., freshwater fish into Budd Inlet and marine fish into Capitol Lake). No information is available about whether this effect actually occurs and, if so, the number and species of fish that may be impacted by the tide gate openings.

Under existing conditions, a predation point exists at the outlet of the 5th Avenue Dam, where anadromous fish must enter and exit the lake through a small fish ladder, thus exposing such fish to predation from marine mammal, avian, and piscivorous fish predators that congregate at the existing bottleneck created at the dam outlet.

4.1.3.3 Marine Habitat

Budd Inlet is the southernmost arm of Puget Sound and is the only inlet in Thurston County fed by a large river, the Deschutes. More sediment is transported by the Deschutes River than by any other river in Thurston County except for the Nisqually River. Budd Inlet is the most heavily developed and most heavily armored of the inlets in Thurston County, with nearly half of the shoreline armored (Coast and Harbor Engineering 2016). West Bay, located within the City of Olympia on the southwest corner of the inlet, is surrounded by development.

Historically, West Bay was a shallow water estuarine tideflat with unrestricted flows from the Deschutes River and numerous small pocket estuaries from Garfield Creek, Schneider Creek, and other small drainages. West Bay was an important ecological connection between Budd Inlet and the adjacent freshwater and upland habitats. The estuary provided a transitional area critical for out-migrating juvenile salmon and returning adults, and the highly productive tideflats of West Bay supported key shellfish species including Olympia oysters, clams, and crabs, and provided habitat for primary production of benthic and epibenthic invertebrates. These filter feeding organisms helped to maintain good water quality in the estuary, and contributed to the diets of fish, birds, and mammals. In addition, tidal flushing occurred frequently, as the intertidal tideflats were exposed during low tides (Coast and Harbor Engineering 2016).

In addition to the ecological effects from estuary disconnection, the shoreline of West Bay has also been directly exposed to numerous ecological impacts from human development, including disconnection of upland habitats from the marine waters, conversion of shallow tideflats into both deeper waters and uplands, reduced sediment supply and large wood inputs from bluffs and rivers and streams, reduced water quality and contamination, and shoreline degradation from fill and armor placement (Coast and Harbor Engineering 2016).

The vast majority of the east shoreline of West Bay is now armored, with industrial, commercial, and residential development in the uplands. The west shoreline has also been impacted, although some segments of semi-natural shoreline still persist. West Bay does not have mapped eelgrass presence or mapped sand lance (*Ammodytes hexapterus*) or Pacific herring (*Clupea pallasii*) spawning, although there are some patchy fringes of both dune grass and approximately 9 acres of patchy fringe salt marsh in the southwest corner of the bay (Ecology 2020b). In addition, the west shoreline has approximately 0.7 mile of mapped surf smelt (*Hypomesus pretiosus*) spawning, centered near West Bay Park (WDFW 2020c); however, forage fish spawning opportunity is generally limited in West Bay.

Dredge and fill activities in West Bay and the construction of Capitol Lake have significantly reduced tideflat habitat in West Bay over the last 150 years. The reduction in the amount of tideflat habitat has reduced habitat for important juvenile salmonid food sources and Olympia oysters. Fill placed between the East and West Bays of Budd Inlet and associated bulkheads and overwater structures have displaced tideflat habitat and degraded intertidal habitat. Dredging has also changed a large intertidal tideflat into deeper subtidal marine habitat, thus increasing water volumes and reducing tidal flushing.

West Bay is on the 303(d) list for DO and bacteria in the water column, as well as exceedances of 2,3,7,8-TCDD (Dioxin), polychlorinated biphenyls (PCBs), and multiple types of polycyclic aromatic hydrocarbons (PAHs) that were detected in sediment bioassays with fish tissue (Ecology 2020a).

Marine Salmonid Habitat

Estuaries are critical habitat features for both juvenile and adult Chinook salmon, providing habitat conditions that support juvenile salmon in their physiological transitions (smolting), refugia from predators, and elevated prey resources relative to freshwater and marine systems (Simenstad et al. 1982; Thorpe 1994; Magnusson and Hilborn 2003; Price and Schreck 2003; Campbell et al. 2017; Sharpe et al. 2019; Chalifour et al. 2020). Chinook salmon require habitats ranging from shallow intertidal tideflat, beach, and marsh used for foraging, migration, and refuge by juveniles to deepwater marine areas used by resident and returning adults (Fresh et al. 2011). Removing the connection between freshwater features and West Bay has degraded the quality and availability of habitat for fish and aquatic species. Impeding the hydrologic connections of the Deschutes River and other streams cut off sediment sources. Sediment inputs are a critical component to healthy beaches and provide suitable substrate for forage fish spawning and invertebrate production, which are important prey resources for Chinook salmon. Surf smelt and sand lance require gravel and sand substrate, respectively, within the middle and upper intertidal ranges, while Pacific herring require macroalgae as substrate to attach their eggs (Penttila 2007). Pacific herring and sand lance (which currently do not spawn in the study area).

The shallow, nutrient-rich waters of the South Sound are optimal rearing conditions for wild Chinook salmon natal to other rivers, as this habitat is known to support wild juvenile Chinook salmon from watersheds as far north as the Green River (TCDLE 2004). In addition, juvenile salmon originating from hatcheries as far north in Puget Sound as the Wallace River, a tributary to the Skykomish River, have been detected in the South Sound, including within Budd Inlet (Steltzner, 2021 pers. comm.).

4.2 WILDLIFE AND WILDLIFE HABITAT

4.2.1 Wildlife Use in Study Area

The study area contains a diverse mix of terrestrial, wetland, and aquatic habitats used by numerous wildlife species. Shellfish, shorebirds, and other wading birds are found on the beaches and tideflats of Budd Inlet, while bats forage in the neighboring riparian areas and Capitol Lake. Various birds and mammals use the freshwater and marine habitats of the Deschutes River and South, Middle, and North Basins. The following sections describe wildlife found in the study area (i.e., organized by shellfish, birds, bats, and other mammals). For each wildlife group, one or two indicator species have been selected for the effects analysis, which are highlighted in the discussion. The emphasis is on wildlife that use habitats expected to be affected by the proposed alternatives – deepwater, freshwater wetlands, and estuarine habitat. Upland habitats are not expected to be widely affected by the proposed project; thus, less emphasis was given to wildlife use of this habitat type.

4.2.1.1 Shellfish

Shellfish include freshwater mussels (within Capitol Lake) and crabs, numerous clams, the Olympia oyster (*Ostrea lurida*), marine mussels, shrimp, abalone, and more (within Budd Inlet).

Western freshwater mussel fauna from the Pacific region, which includes drainages flowing into the Pacific Ocean, Arctic Ocean, and the endorheic Great Basin, is composed of three genera (*Anodonta*, *Gonidea*, and *Margaritifera*). A. *oregonensis/ A. kennerlyi* are historically found in the Puget Sound region and commonly found in these drainages today. Western freshwater mussel (*Anodonta oregonensis*) have been observed in Capitol Lake (Pacific Northwest Native Freshwater Mussel Workgroup 2008).

A*. nuttalliana/A. californiensis* are not likely present in Capitol Lake and found almost exclusively in the Columbia River Basin. *G. angulata* were historically more prevalent in Eastern Washington and found from the Columbia River (Kittitas County); Toppenish Creek (Yakima County); Yakima River (Benton County); the Snake River (Columbia County); Chehalis River (Grays Harbor and Lewis Counties); Skookumchuck River (Lewis County); Spokane River (Lincoln County); the Columbia, Okanagan, Similkameen, Spokane, and Little Spokane Rivers; Osoyoos Lake; Palmer and Hangman Creeks and Spokane Falls (Okanagan County); and Colville River (Stevens County) (WDFW 2022b).

M. falcata have been extirpated from much of the mainstem Columbia and Snake Rivers; substantial declines, die-offs, or lack of recent reproduction have also been reported from the Sanpoil River (Ferry County), Kettle River (Stevens County), the Little Spokane River (Spokane County), Snohomish River, Muck Creek (Pierce County), Bear Creek (King County), and Nason Creek (Chelan County) (WDFW 2022b). In addition, this species inhabits cold creeks and rivers with clear, cold water and sea-run salmon or native trout including waterways above 5,000 feet in elevation, which is not present in Capitol Lake.

Native marine shellfish, such as geoduck clams (*Panopea abrupta*), hardshell clams (e.g., native littleneck [*Protothaca staminea*], butter [*Saxidomus giganteus*], and horse [*Tresus nuttallii*]), and Olympia oysters are of high ecological, economic, cultural, and recreational value in Washington. Within the study area, Olympia oysters occur as scattered individuals and small patches throughout the low intertidal and shallow subtidal habitats of Budd Inlet (Curtis, pers. comm.). Restoration efforts to re-establish this native species in the study area are ongoing. Shellfish recorded by WDFW in Budd Inlet also include green shore crab (*Hemigrapsus oregonensis*), humpy shrimp (*Pandalus goniurus*), bay ghost shrimp (*Neotrypaea californiensis*), blue mud shrimp (*Upogebia pugettensis*), heart cockle (*Clinocardium nuttallii*), bent-nose macoma (*Macoma nasuta*), soft-shell clam (*Mya arenaria*), native littleneck clam, butter clam, manila littleneck clam (*Tapes japonica*), gaper clam (*T. capax*), northern gaper clam (*T. nuttallii*), and moon snail (*Polinices lewisii*) (Hayes et al. 2008). Other shellfish present include geoduck, which were monitored most recently by the Squaxin Island Tribe in 2018, and found during sporadic surveys by WDFW mostly occurring in 1988 and 1990. Due to the impaired water quality from multiple pollution sources and low flushing in Budd Inlet, there are no safe public harvest sites in the majority of Budd Inlet, and WDFW has not conducted general surveys of shellfish.

Indicator shellfish species selected for this project include the **green shore crab** and **native littleneck clam**. Habitat association and use of these species are considered representative of the shellfish species group for the purposes of this analysis. Both species use mud or sandy mud habitats with tidal influence. The green shore crab is a common crab found in the higher intertidal zone of tideflats (Ricketts et al. 1985 as cited in Hayes et al. 2008). In addition, its planktonic larvae and the planktonic larvae of several other crab species can utilize estuaries and nearshore areas as a nursery (D. Lowry, pers. comm., and Telnack and Phipps 2007 as cited in Hayes et al. 2008). The native littleneck clam is found in packed mud or in gravel mixed with sand but seems to prefer clayey gravel (Ricketts et al. 1985 as cited in Hayes et al. 2008). In some areas, it occurs so densely that the valves often touch, such as the level gravel beaches of Hood Canal and Whollochet Bay near Carr Inlet.

4.2.1.2 Birds

Birds in the study area can be described in five groups: shorebirds/wading birds, waterfowl, aerial feeders, raptors, and songbirds. Numerous species in each group use the study area year-round or seasonally for breeding or wintering. WDFW (2008) compiled available data on birds utilizing Capitol Lake and summarized 52 species associated with aquatic habitats or resources of the lake as either permanent (year-round) or seasonal residents. Table 4.6 is a summary of these species-by-species groups and habitat or resource association. The table also notes the specific species selected as indicator species for the impacts analysis, and a brief description of each species follows the table. Indicator species were chosen to represent a wide range of habitat use and foraging strategies to reflect both existing conditions and the range of potential impacts on wildlife. A description of each habitat type and conditions in the study area is provided in Section 4.2.3.

Table 4.6 Bird Species and Species Groups Present in the Study Area

Species Group & Species	Habitat Association & Use	Indicator Species
Shorebirds / Wading Birds		
Greater yellowlegs, spotted sandpiper, dunlin, western sandpiper, least sandpiper, killdeer, short-billed and long-billed dowitcher, great blue heron, green heron	Forage on small invertebrates in shallow water or exposed substrates during low tide; use Capitol Lake only during drawdowns or summer low flows that expose foraging substrates; herons forage on fish, amphibians, and invertebrates; most shorebirds are migratory and only seasonally present, while herons are year-round residents.	Western sandpiper Great blue heron
Waterfowl		
Canada goose, northern pintail, American wigeon, mallard, gadwall, lesser scaup, ring-necked duck, bufflehead, common goldeneye, Barrow's goldeneye, black scoter, surf scoter, hooded merganser, common merganser, ruddy duck, American coot	Forage on aquatic plants in fresh and saltwater, plant seeds and tubers, weeds, aquatic invertebrates (insects, crustaceans, and mollusks); use habitats associated with open water and/or riparian sites for roosting and breeding.	Common goldeneye American wigeon
Aerial Feeders		
Barn swallow, purple martin, northern rough-winged swallow, tree swallow, violet-green swallow, Vaux's swift	Seasonal (spring and summer); forage on flying insects; Capitol Lake is important source for insect production and emerging prey.	Violet-green swallow
Raptors		
Osprey, bald eagle*, Cooper's hawk, merlin, peregrine falcon	Year-round and seasonal use of Capitol Lake and shoreline habitats; prey on shorebirds and ducks (peregrine falcon), small shorebirds (merlin), fish (osprey), birds and fish (bald eagle).	Bald eagle
Songbirds		
Warblers, thrushes, tanagers, sparrows, finches, jays, chickadees, wrens, and other perching birds	Use a wide variety of terrestrial and wetland habitats (freshwater and nearshore) to forage, breed, and over-winter; many permanent residents with some seasonal migrants using habitats for breeding (e.g., warblers, thrushes).	Yellow warbler

*Protected under the federal Bald and Golden Eagle Protection Act.

All bird species listed are protected under the federal Migratory Bird Treaty Act.

As the most abundant shorebird in Washington State, the **western sandpiper** (*Calidris mauri*) can be found along the coast and throughout Puget Sound shoreline habitats, preferring tideflats and sandy beaches. They can be observed during the winter months and during migration to and from their breeding grounds in Alaska. Western sandpipers use their long bills to probe mud and sand substrates to pick insect larvae, crustaceans, mollusks, and other aquatic invertebrates.

Great blue heron (*Ardea herodias*) are wading shorebirds that use the study area year-round for foraging and breeding. They forage in shallow water and along shorelines of fresh, brackish, or saltwater, or in certain types of open terrestrial habitats. Great blue herons consume mostly fish but have a variable diet and also prey on amphibians, invertebrates, reptiles, mammals, and birds. WDFW and local citizens have documented active breeding and rookery locations on forested slopes of both the West Bay and East Bay of Budd Inlet, approximately 4,000 and 6,000 feet from the 5th Avenue Dam, respectively (WDFW 2021). In 2016, the City of Olympia acquired undeveloped properties on the west side of Budd Inlet between West Bay Drive and Rogers Street (known as the West Bay Woods) that support and surround a long-time rookery for great blue heron.

Common goldeneye (*Bucephala clangula*) are waterfowl that are found in the study area during winter primarily in the marine waters of shallow coastal bays, estuaries, and harbors wherever adequate food exists (Bellrose 1980 as cited in Hayes et al. 2008). They forage mostly under water and in shallow protected waters with sandy, gravel, or rocky substrates searching for crustaceans, mollusks, and fish. In contrast, **American wigeon** (*Anas americana*) in the study area primarily use freshwater wetlands to forage on emergent vegetation. Almost entirely herbivorous during overwintering, this dabbling duck consumes stems and leafy parts of aquatic plants, leafy parts of upland grasses, and clovers (Bellrose 1980 as cited in Hayes et al. 2008).

Violet-green swallow (*Tachycineta thalassina*) use the study area during spring and summer for breeding and post-breeding foraging before migrating south during the winter. They forage almost exclusively on flying insects and are one of six species of aerial foraging birds that make significant use of Capitol Lake as foraging habitat (Hayes et al. 2008). Violet-green swallows nest in tree cavities, cliffs, buildings, old woodpecker holes, and nest boxes.

Bald eagle (*Haliaeetus leucocephalus*), along with the other raptor species in the group, are both permanent and seasonal residents in the study area. For breeding, they use large trees in riparian areas associated with both marine and freshwater shorelines as nest sites and forage in adjacent waters. They are generalized in their prey requirements and consume a variety of food such as live and dead fish, ducks, other water birds, and small mammals (Stinson et al. 2001).

The **yellow warbler** (*Dendroica petechial*) is a small songbird found in the study area during spring and summer. In general, it uses brushy habitats on forest edges to forage for insects (e.g., caterpillars), but chooses deciduous forest or thickets near water for breeding. They glean prey from tree branches and foliage and fly out to catch insects in midair.

4.2.1.3 Bats

Capitol Lake supports emerging volant (i.e., flying) insects that are prey for several bat species (Hayes et al. 2008), and currently provides foraging and drinking habitat (Falxa 2004, 2005, 2008).Two bat species in particular – Yuma myotis (*Myotis yumanensis*) and little brown bat (*M. lucifugus*), neither of which are state- or federally listed species – are known to have large local populations that are supported by the roosting habitat provided by the abandoned Woodard Bay trestle, located approximately 7.5 miles from Capitol Lake. These bat species use the trestle for birthing and rearing of pups during the spring and summer months. An estimated 3,000 bats occupy the Woodard Bay trestle colony, with Yuma myotis having the largest population size of the two (Falxa 2004, 2005, 2008). Females aggregate annually in maternity colonies that have a high and stable temperature of 86 to 131 degrees F around April (Whitaker 1996) and give birth to one young between May and June (Allen 1994). Males typically roost in tree cavities, which are likely the original sites for most nursery roosts (BCI 2022).

Use of Capitol Lake by bats roosting in the Woodard Bay trestle has been documented, but the importance of existing Capitol Lake habitats for supporting these bats is not well understood (see Falxa 2004, 2005, 2008). Telemetry studies conducted on the Woodard Bay trestle bat colony showed that 5 of 7 individuals flew to Capitol Lake to presumably drink and forage, but also visited other waterbodies in the area – both freshwater and saltwater (Falxa 2004, 2005, 2008). Ecological needs and associations of these species have been studied in other systems, which found reproductive female and juvenile Yuma myotis bats to predominantly forage within open, uncluttered habitats over land, and low over water (Brigham et al. 1992), although this research was conducted prior to the understanding that Yuma myotis and little brown bats can only be correctly identified with genetics. A study in western Oregon showed that the feeding activity of Yuma myotis was up to eight times higher along forested edges of streams compared to those in logged areas, apparently because the wooded areas contain greater insect diversity (BCI 2022). Although Yuma myotis feed predominantly over water, they eat a variety of insects that include moths, froghoppers, leafhoppers, June beetles, ground beetles, midges, mosquitoes, muscid flies, caddisflies, and crane flies (Whitaker 1996, summarized in BCI 2022). Dietary variation of this species suggests that they forage opportunistically on aquatic insects, with changes in diet reflecting changes in availability (Brigham et al. 1992). Similar to Yuma myotis, little brown bats feed primarily on emerging aquatic insects (especially midges), but moths, beetles, non-aquatic flies, and a variety of other insects and spiders are also eaten (WDFW 2022c,d). Foraging is often concentrated over or near water, but also occurs along forest edges, in forests, over lawns and streets, and in other cover types (WDFW 2022c).

Yuma myotis is commonly observed throughout its wide range throughout western North America, but populations have declined slightly due to destruction of suitable roosting sites and are threatened by loss of riparian habitats (Myers et al. 2022). Little brown bats are abundant across North America (Myers et al. 2022) and thrive with expansion of human populations, which creates roosting sites (Myers et al. 2022), although bioaccumulation of pesticides has resulted in some population declines (Fenton and Barclay 1980; Kunz et al. 1977). Conservation actions for Yuma myotis include avoiding human activities that destroy or degrade riparian habitats and water quality, and the protection of large trees along stream corridors that provide potential roost sites (WDFW 2022d). Conservation actions for little brown bats are restricted to protection of active roost sites (WDFW 2022c).

Other bat species documented in the study area include big brown bats (*Eptesicus fuscus*), silver-haired bats (*Lasionycteris noctivagans*), Townsend's big-eared bat (*Corynorhinus townsendii*), hoary bat (*Lasiurus cinereus*), western long-eared myotis (*Myotis evotis*), and California myotis (*M. californicus*) (Cascadia Research Collective 2011; Hayes et al. 2008; Tobin 2020; Towanda and Falxa 2007). These bats occur in lower densities than the Woodard Bay trestle species, and their use of Capitol Lake habitats is largely unknown.

The little brown bat has been selected as the indicator species for the effects analysis. Like other myotis bats, this species emerges at dusk to feed and eats a variety of insect prey. Aquatic insects such as midges, caddisflies, and mayflies are the primary prey, although beetles, moths, and other kinds of flies are also taken (Nagorsen and Brigham 1993). Their diet changes seasonally in response to insect abundance, with midges predominant in spring and caddisflies and mayflies most important in summer. The little brown bat is able to adjust its hunting techniques quickly to take advantage of insect concentrations and hatches (BCI 2022). After an initial feeding period of 15 to 20 minutes, some individuals have been documented to use temporary night roosts near Capitol Lake (Falxa 2004, 2005, 2008). Although little brown bat females are known to occur in the Woodard Bay trestle colony, they also establish nursery colonies in buildings and other human-made structures, tree cavities, rock crevices, caves, and under the bark of trees (WDFW 2022c). The sexes live separately and the males rarely occupy nursery colonies. The little brown bat hibernates in caves and abandoned mines and does not appear to hibernate in buildings (Nagorsen and Brigham 1993).

4.2.1.4 Other Mammals

Apart from bats (described above), most mammals that use the study area are aquatic or semi-aquatic and primarily visit the area to find prey or forage. WDFW (2008) compiled available information and noted 11 species of freshwater aquatic and marine mammals that have been recorded in the Capitol Lake area. No formal surveys have been conducted, and all records are anecdotal. Table 4.7 summarizes the species and species groups of mammals and is followed by a brief description of the indicator species selected for the effects analysis.

Table 4.7 Mammal Species and Species Groups Present in the Study Area

Species Group & Species	Habitat Association & Use	Indicator Species
Freshwater Aquatic Mammals		
Nutria*, muskrat, beaver, northern river otter, mink, raccoon	Some forage on aquatic plants and emergent vegetation of wetlands and generally use freshwater wetlands and streams (nutria, beaver, raccoon); some use estuarine and nearshore habitats to prey on aquatic birds, crayfishes, fishes, and amphibians (otter, mink).	Northern river otter

Species Group & Species	Habitat Association & Use	Indicator Species
Marine Mammals**		
Orca***, harbor seal, California sea lion	Seasonal and migratory use of marine waters to prey on salmon and other fish species during seasonal runs.	Harbor seal Orca

*Nutria are considered an aquatic invasive species in Washington State and are classified as a Prohibited Level 3 Species (WAC 220-640-050).
** All marine mammals are protected under the federal Marine Mammal Protection Act.
*** Southern Resident Orca are listed as Endangered under the federal Endangered Species Act.

Northern river otter (*Lontra canadensis*) are medium-sized aquatic carnivores that forage in and along aquatic, estuarine, and marine nearshore habitats. They are opportunistic feeders capable of taking a diversity of aquatic prey, including larger animals (e.g., turtles), but typically prefer fish. They are a generalist species and adapt their forage and behavior patterns to a variety of habitat types and conditions. River otter are known to use Capitol Lake as documented by nuisance trapping efforts and WDFW data (Hayes et al. 2008).

Harbor seals (*Phoca vitulina*) are regionally common residents in South Puget Sound that prey on fish and haul out on land to rest and breed. In the study area, harbor seals are especially evident near the 5th Avenue Bridge/Dam fish ladder during the August–September fall Chinook salmon migration, with up to 15 animals visible at once (K. Keown, pers. comm. and R. Beach, pers. comm., as cited in Hayes et al. 2008). Based on the WDFW Seal and Sea Lion Atlas (WDFW 2000), no haul-out sites exist in the area that Capitol Lake now occupies, but some non-mapped haul-out sites have been documented in Budd Inlet where small aggregations (1–3) of harbor seals have been observed (Hayes et al. 2008). Harbor seals from these various haul-out sites may be some of the same individuals that visit the dam fish ladder. Overall, 30–40 harbor seals are thought to regularly occupy Budd Inlet (S. Jeffries, pers. comm., as cited in Hayes et al. 2008).

Hayes et al. (2008) states that it is unclear whether harbor seals are attracted specifically to the availability of fall-run Chinook salmon, and return to south Puget Sound at other times of the year during runs of coho salmon, chum salmon, and steelhead trout or other marine fish. In general, seal abundance declines after fall-run Chinook salmon stop running. However, seals may revisit the 5th Avenue Bridge/Dam fish ladder simply as a result of foraging nearby. The availability of readily accessible food at the dam fish ladder may play a role in maintaining more harbor seals in lower Budd Inlet than might otherwise be present.

Orca (*Orcinus orca*)**,** or **killer whales**, are long-lived, highly social marine mammals that are found in the wider Salish Sea during spring, summer and fall. There are two distinct types of killer whales commonly found in Puget Sound: the southern resident (fish eating) and the transient (marine mammal eating) whales. The southern residents are found coastally from central Southeast Alaska to central California, and the west coast transients occur from Southeast Alaska to southern California (Wiles 2016). The southern resident population is listed as endangered under the federal ESA and consists of three designated pods – J, K, and L. Whales of the same pod spend most of their time together and contain several females and her descendants. The transients (also called Bigg's whales) display a more fluid social organization and are more mobile than the southern residents, travelling greater distances and having greater home ranges (Wiles 2016). Both types have been observed in study area, but orcas in Budd Inlet are typically transient whales. Chinook salmon are the preferred forage species for resident orcas, while transient orcas primarily forage on marine mammals, including seals and sea lions.

The state of Washington, under the direction of Governor Inslee, recently completed a final report and recommendations for ensuring the survival of orcas in Puget Sound. The Southern Resident Task Force led this work, which was completed in 2019 (Southern Resident Orca Task Force 2019).

4.2.2 Listed or Sensitive Wildlife Species and Habitats

The southern resident population of the killer whale is listed as endangered under the federal ESA (NMFS 2005), and critical habitat is currently designated for inland waters of Washington State including the study area. Other listed species are described below.

Giant chain fern (*Woodwardia fimbriata*), a state-listed sensitive plant species typically found in damp coastal forests, is mapped as currently occurring within the east portion of the study area (DNR 2020). Additionally, tall agroseris (*Agoseris elata*), a state-listed sensitive plant species found meadows, open forests, and exposed rocky ridges, is mapped as historically occurring throughout the study area (DNR 2020). Both plant species are perennial forbs native to Washington State.

Townsend's big eared bat, a state candidate species, has been detected in the South Basin area through acoustic detection, but no information is available about the specific habitats used by the species or its frequency of occurrence in the study area (WDFW 2021, 2022b). Although Yuma myotis and little brown bats do not have state or federal protections, as they are thought to both be common, widely distributed species (Myers et al. 2022; WDFW 2022c,d), myotis roosting concentrations are listed as a Priority Habitat under the state Priority Habitats and Species (PHS) program (WDFW 2021).

The area including Capitol Lake, Percival Cove, and the riparian corridor associated with Percival Creek is considered a biodiversity area (native habitat within an Urban Growth Area) by WDFW PHS mapping for its terrestrial habitat and remnant wooded shoreline, which provide nesting and foraging habitat for wildlife (WDFW 2021).

4.2.3 Habitat Conditions in Study Area

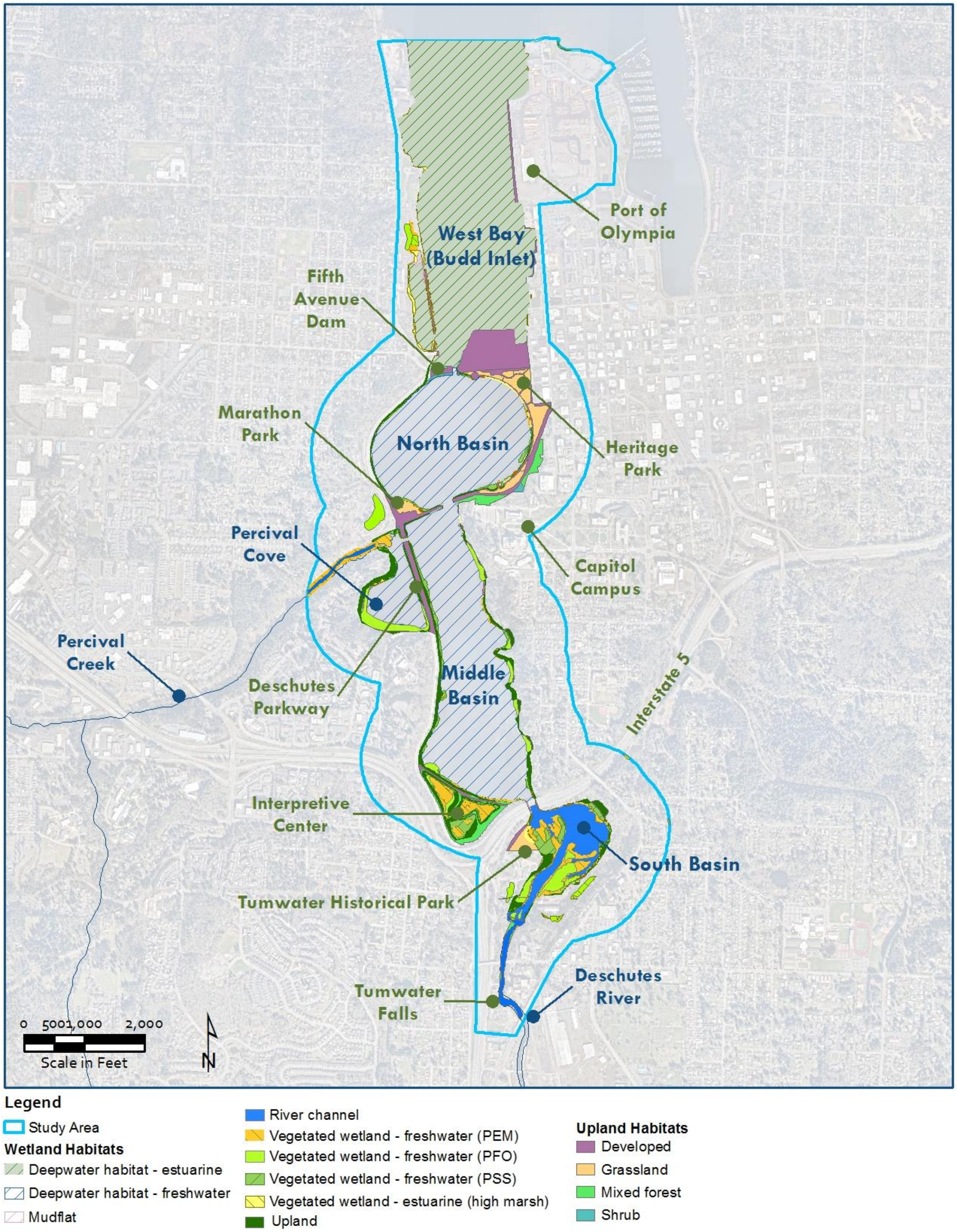
To identify and map wildlife habitat in the study area, two data sources and methods were used. For upland habitats such as forest habitat, the Coastal Change Analysis Program (C-CAP) data and method of categorizing vegetation were used to map forest, shrubland, and open space (NOAA 2016). For wildlife habitats that involve wetlands, the wetland types developed for the *Wetlands Discipline Report* (ESA 2022) were incorporated here. However, several wetland classes have been combined to represent two wildlife habitat types for wetlands: freshwater wetlands and estuarine wetlands. These data and various aerial imagery were used along with field reconnaissance to create a map of existing wildlife habitat types in the study area (Figure 4.2). The types, the extent of each type within the study area, and the indicator species (described above) that are associated with each type are summarized in

Table 4.8. A brief description of each habitat type and conditions in the study area is provided after the table.

Table 4.8 Wildlife Habitat Types in Study Area

Habitat Types	Estimated Area (acres)	Indicator Species Use
Freshwater wetland	52	Great blue heron, American wigeon, violet-green swallow, bald eagle, yellow warbler, little brown bat, northern river otter
Deepwater habitat - Freshwater	240	American wigeon, violet-green swallow, little brown bat, northern river otter
Mixed forest	126	Great blue heron
Shrub land	7	Yellow warbler
Open space (Developed)	17	Violet-green swallow
West Bay only		
Deepwater habitat - Estuarine	208	Green shore crab, littleneck clam, common goldeneye, bald eagle, northern river otter, harbor sea, orca
Estuarine wetland	4	Green shore crab, native littleneck clam, Western sandpiper, great blue heron, common goldeneye, bald eagle, northern river otter, harbor seal, orca

Figure 4.2 Wildlife Habitats in the Study Area



4.2.3.1 Wetland Habitats

Wetland habitats in the study area include freshwater and estuarine wetland communities, as described in the following sections.

Freshwater Wetlands

Freshwater wetlands provide scattered patches of habitat for waterfowl and shorebirds along with aquatic mammals. As described in Section 4.1.2.2, Capitol Lake is relatively shallow with a mean depth of 9 feet. The shallow waters result in eutrophic conditions, leading to reduced water quality (elevated fecal coliform counts, phosphorus levels, and Eurasian watermilfoil development) and thus the quality of the lake for a suite of native organisms. However, this high productivity likely enhances Capitol Lake as a producer of flying insects with aquatic larval stages (Herrera 2005). This insect production appears to be an important foraging base for several species of bats and birds, such as swallows and other aerial feeders. In particular, the maternal roost of over 3,000 Yuma myotis and little brown bats from Woodard Bay and at least one substantial roost (500+ individuals) from another nearby location may depend on Capitol Lake while rearing young (Falxa 2007, Hayes et al. 2008). Vaux's swifts (*Chaetura vauxi*), also entirely dependent on flying insects, are known to preferentially forage over freshwater aquatic habitats (Bull and Beckwith 1993, as cited in Hayes et al. 2008). At least one other bat species (Townsend's big-eared bat) and several species of swallows are known to forage for insects emerging from or flying over Capitol Lake, but how dependent these species are on flying insect production derived from this aquatic-habitat is unclear (Hayes et al. 2008).

Freshwater wetlands are also present throughout the Middle Basin, Percival Cove, and South Basin including palustrine forested, scrub-shrub, and emergent wetlands (see the *Wetlands Discipline Report* for detailed characterization). In the Middle Basin, the shallow waters and Percival Cove provide waterfowl habitat while scattered patches of wetland along edges support songbirds and raptors. Constructed wetlands in the south end of the Middle Basin, within Interpretive Center, provide additional deepwater and emergent wetland habitat for wildlife. Percival Cove includes emergent and scrub-shrub wetlands that offer foraging, roosting, and breeding habitats for dabbling ducks, geese, and grebes, as well as wading birds like great blue heron. Wildlife habitat in the South Basin includes wetlands associated with the Deschutes River and patches of scrub-shrub and emergent wetlands near Tumwater Historical Park.

Estuarine Wetlands

The West Bay of Budd Inlet is primarily deepwater estuarine habitat but also supports some tideflats, and estuarine wetland habitats on the west side of the Bay. Despite historical modification of the Deschutes River system, loss of tideflat habitat, and shoreline armoring, as described previously in Section 4.1.2.3, the estuarine waters of the West Bay are productive and support a marine food web critical to multiple species groups and individual species of wildlife. The brackish waters promote high biological activity and food for diving ducks and shorebirds as well as marine mammals. The remaining beaches, tideflats, and nearshore provide patches of habitat for crab, shrimp, clam, and other types of shellfish, including Olympia oyster.

4.2.3.2 Forest Habitats

The study area contains patches of disconnected or contiguous forest habitats including conifer, deciduous, and mixed forest (i.e., conifer and deciduous). Figure 4.2 shows the distribution of forest types in the study area. The forest types are based on the C-CAP data and classification system, which distinguishes forest patches by dominance (greater than 75%) and that have at least 20% of the total vegetation and taller than 16.5 feet in height.

Mixed forests are dominated by all trees, including conifer and deciduous, with neither group providing more than 75% of total cover. Mixed forest is the most common forest type with approximately 126 acres present in the study area. Mixed forest is present adjacent to Percival Cove, the east side of the Middle Basin, and along the east and south riparian shorelines of the South Basin. These habitats provide roosting and nesting trees for bats, great blue heron, and raptors such as bald eagle and osprey (*Pandion haliaetus*). Numerous species of songbirds use forest habitats on a year-round or seasonal basis for breeding.

4.2.3.3 Shrubland

Shrubland habitat is dominated by low-growing vegetation such as rose, salal, and blackberry, that provide more than 20% of the total vegetation and are less than 20 feet tall. This vegetation type includes shrubs, young trees, and/or landscape trees. This habitat is very limited in the study area. Small patches are present within West Bay Park and the shoreline of Budd Inlet. The western portion of the Capitol Lake shoreline supports a narrow fringe of upland shrub habitat between the shoreline of the lake and Deschutes Parkway SW. This fringe of shrub habitat is also present between Percival Cove and the Middle Basin. These narrow edge habitats likely provide temporary resting or roosting areas for songbirds using the study area and for waterfowl using the freshwater habitats.

4.2.3.4 Open Space (Developed)

Open space (developed) is dominated by managed and manicured grasses and/or low-lying vegetation, including parks. The largest area of open space is present on the eastern shoreline of Capitol Lake within Heritage Park. This patch of habitat is regularly maintained through mowing and has a high level of human activity, and thus supports limited use by wildlife. Marathon Park at the south end of Capitol Lake also supports some limited grass (maintained) habitats that may provide foraging or resting areas for songbirds or waterfowl.

4.3 TRIBAL RESOURCES

The Capitol Lake – Deschutes Estuary Project is located within the ancestral lands of the Southern Coast Salish and Southwestern Coast Salish cultural groups, which include but are not limited to the Steh-chass People of the Squaxin, the Nisqually, and the Chehalis. These groups have used the area since time immemorial for various levels of habitation, ceremony, and resource gathering. Descendants of these people are members of today's federally recognized Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation.

In 1854 Joel Palmer, Oregon Territory Superintendent of Indian Affairs, and Isaac I. Stevens, Washington Territory Governor and Superintendent of Indian Affairs, negotiated the Medicine Creek Treaty with indigenous people in the Southern Puget Sound region (Ecology 2009). Under this treaty, ratified in 1859, lands in the Southern Puget Sound stretching from the Cascades to the Black Hills and south to the Skookumchuck River were ceded to the U.S. Government by the treaty signatories. This area includes the ancestral lands of the Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation (Ecology 2009; Marr et al. 1980). This treaty between the U.S. Government and signatories recognized certain retained rights, including the following under Article 3:

"The right of taking fish, at all usual and accustomed grounds and stations, is further secured to said Indians in common with all citizens of the Territory, and of erecting temporary houses for the purpose of curing, together with the privilege of hunting, gathering roots and berries, and pasturing their horses on open and unclaimed lands: Provided, however, That they shall not take shellfish from any beds staked or cultivated by citizens, and that they shall alter all stallions not intended for breeding-horses, and shall keep up and confine the latter" (Treaty of Medicine Creek, 1854).

These retained treaty rights are referred to today as "Usual and Accustomed Areas" or "U&A areas" and have been subject to repeated litigation (Bernholz and Weiner 2008). In 1974, these rights were upheld in a landmark court case decided by Judge Boldt and upheld by the U.S. Supreme Court in 1979 (NWIFC 2020a). The Washington State Attorney General's Office has summarized the adjudicated U&As for off-reservation treaty fishing rights of Western Washington tribes based upon the findings of Judge Boldt and other sources, including court orders pertaining to U&A areas (Washington State Attorney General's Office 2007). No U&A areas are listed for the Confederated Tribes of the Chehalis Reservation, presumably because they are not signatories of the Treaty of Medicine Creek. The Attorney General's document identifies the following U&As for the Squaxin Island Tribe and the Nisqually Indian Tribe.

Nisqually Indian Tribe

- Saltwaters areas of the mouth of the Nisqually River and surrounding bay
- Nisqually River & tributaries
- McAllister (a/k/a Medicine or Shenahnam) Creek
- Squalticu Creek
- Chambers Creek
- Lakes between Steilacoom and McAllister Creeks
- All saltwater areas of southern Puget Sound from the northernmost tip of the area generally known as Henderson Bay south to the Nisqually River bay area to a line drawn from Johnson Point to Devils Head; from a line drawn east from Point Fosdick on Kitsap Peninsula to Day's Island south of the Nisqually River bay area (to a line drawn from Johnson Point to Devils Head); and all waters between Henderson Bay and the Narrows (to

a line drawn from Point Fosdick to Day's Island) including Carr Inlet and Hale Passage; as well as all the freshwater rivers and streams which drain into that area

Squaxin Island Tribe

- Shallow bays, estuaries, inlets, and open waters of Southern Puget Sound
- Freshwater streams and creeks draining into those waters
- Saltwater north and west of line drawn from Mahnckes Point (Kitsap Peninsula) to the westernmost point of McNeil Island bordering Pitt Passage then extending from Hyde Point on McNeil Island to Gibson Point on Fox Island and then extending from Fox Point on Fox Island to Point Fosdick on the Kitsap peninsula, generally known as the Carr Inlet/Henderson Bay/Hale"

The U&A areas for the Squaxin Island Tribe as described above by the Attorney General's Office appear to coincide with the project boundaries.

The Nisqually Indian Tribe and Squaxin Island Tribe are members of the Northwest Indian Fisheries Commission, which formed after the Boldt decision and provides natural resources management support to member tribes. Salmon are among some of the most significant resources that contribute to the spiritual and cultural identity of the treaty tribes. The traditional diet of the Southern Coast Salish relies heavily upon salmon, but also includes other important saltwater, freshwater, and terrestrial resources. Historically, the inlets surrounding the southernmost portion of Puget Sound would have provided abundant resources. For further discussion, see the *Cultural Resources Discipline Report* (ESA and NW Vernacular 2022). The tribes have been actively involved in salmon recovery efforts throughout their U&A areas.

5.0 Impacts and Mitigation Measures

5.1 OVERVIEW

This section describes the probable fish and wildlife impacts from the No Action Alternative and the action alternatives (Managed Lake, Estuary, and Hybrid Alternatives). This section also identifies mitigation measures that could avoid, minimize, or reduce the identified impact below the level of significance.

5.2 NO ACTION ALTERNATIVE

The No Action Alternative would not result in construction impacts on fish and wildlife because the project would not be built. Under the No Action Alternative, the 5th Avenue Dam would remain. Potential impacts would be related to limited ongoing maintenance of the 5th Avenue Dam and ongoing sedimentation of the Capitol Lake – Deschutes Estuary, since no sediment management strategies would be implemented.

5.2.1 Fish

The lack of active lake management to remove sediment and submerged aquatic vegetation could continue to affect habitat quality and habitat use by some fish or other aquatic species. Under existing conditions, sediment accumulation in the Capitol Lake Basin increases the elevation of the lake bed approximately 3 feet every 25 years (Moffat & Nicol 2020). Sediment would continue to accumulate in the North Basin, resulting in a shallower lake, while sedimentation within the habitats in the Middle and South Basins would continue a slow transition from riverine to wetland habitat, reducing the aquatic habitat area. Water depths and velocities in the main river channel would be maintained, or slightly increased compared to existing conditions. Shallow lake areas can increase the water temperature and decrease DO, negatively impacting salmonids. Sediment accumulation can also disconnect the river channel from adjacent wetlands, resulting in a simplified system with little habitat heterogeneity and impacting rearing habitat for species such as coho salmon. The growth of both native aquatic plant species and invasive species would also continue, which would generally have a negative impact on salmon and a mixed effect on freshwater fish, depending on the species. As described in Section 4.1.1.2, Eurasian watermilfoil has the greatest potential to negatively affect fish and fish habitat, particularly for salmon, and would continue to persist in the lake, with its distribution in the lake potentially expanding. The mats reduce sunlight and oxygen in underlying waters, thus degrading water quality, outcompeting native vegetation, and decreasing habitat quality for native fish species. Watermilfoil treatment and control activities have occurred in Capitol Lake since 2004; however, the species continues to spread, reaching all three lake basins and Percival Cove (see the *Aquatic Invasive Species Discipline Report* for details [Herrera 2022b]).

While the habitat changes from continued deposition of sediment in Capitol Lake would impact salmon, warmwater resident fish species (e.g., smallmouth bass) may benefit from such changes as they have higher temperature tolerances and utilize aquatic vegetation (e.g., watermilfoil) for cover during feeding. Many of these species are piscivorous and prey on salmonids, so increases in their populations may increase the predation of juvenile salmonids. In addition, under the No Action Alternative, water and sediment quality conditions in the North Basin would generally be maintained and are not expected to result in impacts on fish species (Herrera 2022a). Maximum current velocities in Capitol Lake are not predicted to change substantially over time, when considering two representative, extreme hydrologic events (flooding events and future sea level rise) (Moffatt & Nichol 2022).

As Capitol Lake fills with sediment over time, and in the absence of maintenance dredging, the capacity of the lake to act as a sediment sink would be reduced, and ultimately eliminated. Sedimentation rates in Budd Inlet would increase over time, producing shallower marine habitat on the east shoreline of West Bay and potentially decreasing habitat suitability for benthic-oriented marine fish while benefitting shoreline-oriented marine fish. The quality of the water entering Budd Inlet would become increasingly similar to that of the Deschutes River as the lake becomes more river-like (higher dissolved inorganic nitrogen, fewer algae, and less variable DO and pH), but these changes would be small in comparison to the existing conditions in the inlet and are not expected to have a meaningful effect on fish.

Under the No Action Alternative, impacts on fish and aquatic habitat would be **less-than-significant** because the changes described above would occur incrementally and would not be expected to cause a species or species group to be extirpated from the study area.

5.2.2 Wildlife

The No Action Alternative would not result in construction impacts on wildlife or vegetation because there would be no construction. Potential impacts would be limited to the ongoing maintenance of the 5th Avenue Dam and continued sedimentation of the Capitol Lake – Deschutes Estuary, since no sediment management strategies would be implemented. However, limited management of nuisance and invasive species would continue.

As sedimentation of the Capitol Lake Basin continues, there would be a corresponding transition from shallow, deepwater areas to emergent wetland dominated by a variety of rushes, sedges, and cattails. Eventually, woody plants (such as Douglas spirea and salmonberry) would gain a footing and the emergent wetland would transition to a scrub-shrub or forested wetland. This transition would take place over a period of decades and would have a corresponding effect on the types of species that could be supported. Significance determinations are made for each species group below.

5.2.2.1 Shellfish

Sediment would continue to fill the basin, and eventually more sediment would be transported through the dam. This would lead to additional deposits of sediment in areas of Budd Inlet, particularly closer to the dam. This increase in sedimentation would have detrimental impacts on benthic invertebrates such as Olympia oyster; green crab; little neck, butter, and horse clams; mussels; and moon snails. The impacts would not be immediate as it would take decades for the sediment to build up in the basin to a point where most of it was transported to Budd Inlet.

Water quality may be adversely affected as emergent and woody plants encroach into the basin as the lake becomes more shallow with a corresponding nutrient and sediment load transferred to the estuary. Fallen leaves and decaying vegetation in the basin would likely increase the biological oxygen demand (BOD) within the lake, and water exiting the basin would have decreased oxygen levels, further affecting benthic invertebrates in Budd Inlet. However, these changes would not affect regional populations of shellfish and thus the impact would be **less-than-significant**.

5.2.2.2 Birds

The following narrative describes the anticipated impacts of the No Action Alternative on species groups of birds and the associated indicator species.

Shorebirds/Wading Birds

The slow transition from deepwater shoreline to vegetated wetlands would eventually eliminate most foraging habitat for those species that use shallow open water for foraging. Great blue herons can forage in areas 3 feet or so deep, and may be able to find small pocket openings in emergent wetlands, but eventually these areas would become scarce as sediment fills the basin and the density of wetland vegetation increases. Spotted sandpipers use the margins of lakes and wetlands and may be able to find small areas for foraging in the margin between vegetated wetlands and the adjacent uplands. The amount of habitat for both of these common species would be substantially decreased from the existing conditions. This is considered **a less-than-significant** adverse impact on this species group.

Waterfowl

Waterfowl, such as dabbling ducks, feed in shallow areas on vegetation and invertebrates, while diving ducks and other waterfowl forage in deeper water. As open water decreases with increased sedimentation and rising vegetation density, habitat for these birds would be reduced substantially. The numbers of common goldeneye, a diving duck, and American wigeon, a dabbling duck, would decrease as the lake habitat transitions to a vegetated wetland. This is considered **a less-than-significant** adverse impact on this species group.

Aerial Feeders

Aerial feeders depend on insects emerging from the lake for prey. As the lake transitions to vegetated wetland, the number of emergent insects would decrease substantially. Violet-green swallows do not solely depend on water-born insect and forage on a variety of other invertebrates such as leaf hoppers, aphids, beetles, and flying ants that can be found higher above the ground. So while the reduction in the amount of emergent insects may have some effect on the prey availability for these birds, they are versatile feeders not overly depending on the lake habitat. There would be a **less-than-significant a**dverse impact on this species group from the transition from a lake to wetland habitat.

Raptors

The impact of the No Action Alternative on raptors is variable, depending on the species under consideration, but effects would be **less-than-significant**. Cooper's and sharp-shinned hawks, for instance, may find more small to medium-sized songbirds available for prey as the lake transitions to an emergent and scrub-shrub or forested wetland.

The indicator species for this group is the bald eagle, which primarily feeds in open water for fish. The change in habitat from open water to wetland would reduce foraging opportunities for bald eagles, limiting their feeding area to the deepwater portion of the channel. Bald eagles would likely reduce or eliminate their use of this area and shift to nearby freshwater lakes or nearby estuaries.

Songbirds

This wide-ranging and variable group of songbirds responds well to increased habitat interspersion and foliage height diversity. As the lake transitions to an emergent and then a scrub-shrub wetland, the corresponding increase in habitat diversity would contribute to an expected increase in the numbers and types of songbirds that use the area. Yellow warbler, the indicator species for this group, would likely increase in occurrence as the wetlands transition to scrub-scrub and offer additional nesting and foraging areas compared to the deepwater lake habitat.

For these five bird species groups, the changes would not decrease the regional population of these species and thus the impact would be **less-than-significant**. The resulting habitat transition would provide a **moderate beneficial effect** for songbirds.

5.2.2.3 Bats

As described above, the Woodard Bay trestle bat colony includes approximately 3,000 Yuma myotis and little brown bats, with at least some individuals being documented using Capitol Lake for foraging and/or drinking (Falxa 2004, 2005, 2008). These populations have also been documented using other sites and habitats in the region including open water, riparian corridors, forested areas, and parkland (Falxa 2004, 2005, 2008). The No Action Alternative would result in no substantive changes to existing conditions that are currently maintaining the constructed Capitol Lake and associated habitats. The transition of the lake to vegetated wetlands could reduce insect foraging opportunities, but most of those impacts would be realized beyond the 30-year time horizon of the project. Therefore, it is anticipated to result in a **less-than-significant** impact on the bats using the Woodard Bay trestle, as well as other bat species who reside in the area.

5.2.2.4 Other Water-Dependent Mammals

Fish-eating species, such as the river otter, would likely decline within the basin as deepwater areas transition to wetland and reduce the fish carrying capacity of the lake as it fills with sediment. Other species, such as muskrat, may increase in density and occurrence as emergent wetland slowly encroaches into the lake. Raccoons are a versatile and common species likely to be unaffected by the habitat transition. As the lake transitions to a wetland habitat, river otters may be more limited in their occurrence to upstream areas of Percival Creek where foraging opportunities are better than the vegetated wetlands.

Marine mammals would likely experience negligible adverse impacts from the transition of the lake to wetland and the lack of sediment management activities. Resident orcas are highly dependent on salmon, and the decrease in fish habitat and the expected decrease in DO from increased BOD would have a negligible effect on orca forage opportunities as the contribution of the basin to Chinook salmon population is minimal and orcas do not typically frequent Budd Inlet. Orcas that do occasionally visit Budd Inlet are more likely to be transient orca and not the Endangered Southern Resident whales. Likewise, these effects would be similar for harbor seals that feed in Budd Inlet. These impacts would be **less-than-significant**.

5.2.3 Summary of Impacts – No Action Alternative

In general, impacts on fish and aquatic habitat would be **less-than-significant**. For wildlife species, the alterations in habitat under the No Action Alternative would generally represent impacts that are **less-than-significant** for most species groups and indicator species, including fish, shellfish, birds, and water-dependent mammals.

Under the No Action Alternative, continuation of current, limited management practices would not benefit species of importance to the Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation, specifically salmon and shellfish. The impacts on salmon related to habitat changes from continued deposition of sediment in Capitol Lake would likely not measurably affect fish available for harvest.

5.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

5.3.1 Fish

5.3.1.1 Impacts on Fish from Construction (Common to All Action Alternatives)

All action alternatives – Managed Lake, Estuary, and Hybrid – have construction impacts associated with the following:

- Initial dredging in the North Basin; or North and Middle Basins

- Construction of habitat areas in the Middle Basin; or North and Middle Basins
- Construction of recreational amenities (boardwalks, dock, and boat launch)

The freshwater in-water work window would extend from June 1 to August 15 and November 15 to February 15 each year, based on project-specific initial coordination with the regulatory agencies. This is similar to the prescriptive in-water work window of the adjacent marine water, which extends from July 15 through February 15 each year. Construction would occur over a 4- to 8-year period. The project would obtain all necessary federal, state, and local environmental permits and approvals for all action alternatives.

The range of potential impacts associated with the main construction elements is described below.

Initial Dredging and Creation of Habitat Areas

All of the action alternatives include dredging, either in the North Basin or in the North and Middle Basins (Table 5.1), as well as the placement of dredged sediments in the Middle Basin into temporary constructed containment cells to create habitat areas. These actions can affect fish from the entrainment of organisms during dredging and increases in turbidity from dredging and spoil placement.

Table 5.1 Comparison of Construction Impacts from Dredging

Initial Dredging Parameter	No Action Alternative	Managed Lake Alternative	Estuary Alternative	Hybrid Alternative
Initial Dredging	No	Yes	Yes	Yes
Dredging Location	n/a	North Basin	North and Middle Basins	North and Middle Basins
Dredging Volume (CY)	n/a	350,000[a]	525,000[b]	500,000[c]
Months of Dredging (approximate)	n/a	12	15	15
In-water Work Seasons Required for Dredging	n/a	2	3	3
Habitat Island Formation from Dredge Spoils	No	Yes	Yes	Yes
Sheet Piling for Dredged Material Containment Cells (LF)	n/a	32,000	34,000	24,000

[a] All dredged material would be reused on-site for habitat island creation.
[b] 513,000 CY would be reused on-site for habitat island creation and shoreline enhancement, while 13,000 CY would require export.
[c] All dredged materials would be reused on-site for habitat island creation and shoreline enhancement.

Entrainment and Direct Mortality

Dredging activities would generate short-term and localized increases in suspended sediments and increase in-water turbidity levels. Dredging can injure or kill fish captured or entrained in the sediment and associated water removed during the activity (Reine and Clarke 1998), as well as result in mortality to fish eggs and larvae in the benthic environment (Wegner et al. 2017). Dredging in the North and Middle Basins and dredge placement to establish habitat areas in the Middle Basin both present a risk of entrainment and injury or mortality under all action alternatives.

The magnitude and extent of these potential effects of entrainment on fish in Capitol Lake would depend on the type of dredge equipment and areal extent of dredging. For all action alternatives, dredging would be completed by a small hydraulic high-volume dredge, but could be supplemented by a mechanical dredge depending on sediment characteristics. Hydraulic dredging tends to entrain more organisms, including fish, than does mechanical dredging, as the former creates stronger suction fields than mechanical dredging (which fish are generally able to avoid, with a potential exception of bottom-fish).

The extent of dredging is similar for the Estuary and Hybrid Alternatives (see Table 5.1); however, both alternatives have substantially more dredging (60 and 43% more dredge volume, respectively) than under the Managed Lake Alternative, primarily because dredging under the Managed Lake Alternative would occur only in the North Basin, while under the other two action alternatives additional dredging would also occur in the Middle Basin. The Estuary and Hybrid Alternatives would also both involve approximately 3 months more of dredging that would the Managed Lake Alternative, at 15 months versus 12 months, a 25% increase in dredge duration.

Since substantially more dredging would occur under the Estuary and Hybrid Alternatives than the Managed Lake Alternative, the potential for detrimental impacts on fish would be greater in those alternatives. However, under all action alternatives, dredging impacts would be somewhat localized at any given time, and adherence to state and federal timing restrictions on in-water work will ensure that there would be no direct impacts on anadromous salmon, including outmigrating juvenile salmon in the spring and early summer. Smaller anadromous (e.g., stickleback) and resident freshwater fish would have the greatest potential for impact; however, BMPs during dredging will be employed to reduce the potential for entrainment impacts on fish, such as the use of a closed versus open clamshell dredge (if mechanical dredging is used).

In addition, the potential impacts of placing dredged materials to create habitat areas include burying existing plants and animals in the containment cell locations. The implementation of fish exclusion, such as turbidity curtains, and fish removal/relocation would substantially reduce the potential of any such impacts on both anadromous and resident freshwater fish.

Some mortality and injury to fish from initial dredging are expected to occur (individual fish could be harmed or killed and larvae of some species could be entrained). However, the vast majority of fish would avoid the areas of active dredging due to increased turbidity (see below). Although individual fish would be impacted, these impacts are small and would not measurably affect the local populations of either anadromous or freshwater resident fish present in Capitol Lake and are considered **less-than-significant.**

Turbidity and Sedimentation

Dredging and dredged material placement for habitat area establishment would generate short-term and localized increases in suspended sediments and turbidity in the lake at and adjacent to the areas being dredged and adjacent to the containment cells where dredged material would be pumped into the cells to dewater the sediments where spoils would be placed. Excessive suspended sediments resulting in turbidity can have physiological and behavioral effects on fish, including clogging fish gills, avoidance, and impaired foraging (Bash et al. 2001). Dredging activities would be regulated under a water quality permit, which would define required BMPs, set allowable mixing zones, and set monitoring requirements. For dredging activities in the lake basin, the mixing zone for rivers and streams would apply, which is 300 feet (see the *Water Quality Discipline Report*).

The factors affecting the magnitude of turbidity generated are essentially identical to that described above under entrainment, specifically the extent of dredging (both areal and temporal) and the type of dredge equipment used. As with entrainment, the amount of suspended sediments and turbidity for the Estuary and Hybrid Alternatives would be somewhat greater than under the Managed Lake Alternative, indicating a higher potential for impacts from turbidity for those alternatives.

However, dredging impacts would be somewhat localized at any given time, and adherence to state and federal timing restrictions on in-water work will ensure that there would be no direct impacts on juvenile salmonids outmigrating in the spring and early summer. Returning adult anadromous salmonids have higher tolerances to turbidity (Newcombe and Flagg 1983) and should generally avoid active dredging areas. BMPs during dredging will be employed to reduce sediment suspension and turbidity and reduce the potential for adverse impacts on fish, such as the use of a closed versus open clamshell dredge (if mechanical dredging is used).

Turbidity generated from dredged material placed in the containment cells and would be minimized by allowing the sediments sufficient time to dewater before more material is placed in the cell. In addition, silt curtains would be deployed to help control turbidity outside of the fill site. Water quality in the cells will be monitored, and if turbidity levels are high, additional treatment methods would be applied before the water is allowed to re-enter the lake. This could include pumping water from the cells to an on-land treatment system (such as a Baker tank located outside of sensitive areas) that would treat the water.

For all action alternatives, the magnitude and extent of turbidity are expected to be minor, short-term, and localized based on the use of the BMPs described above. Although some behavioral impacts on fish would likely occur, such as avoidance and temporary behavioral changes, no substantial mortality is expected to result. Deposition of sediment on the lake bed from construction-generated suspended sediment would not be substantial and would be comparable to the natural deposition from sediment transported from the Deschutes River. For all action alternatives, impacts from dredging-associated turbidity and sedimentation on anadromous fish (including salmon) as well as resident freshwater fish would be **less-than-significant**.

Water Quality

In addition to increased temporary and localized turbidity, water quality effects from dredging and dredged material placement could include decreased DO (due to increased BOD from suspended and dissolved organic matter), and reintroduction of previously buried nutrients to the waterbody (Herrera 2022a). In the most severe cases, this process can cause anoxia (low oxygen levels) and result in harm or mortality to fish. However, based on the chemistry of the benthic material on the bottom of the lake, and the use of hydraulic dredging versus mechanical dredging as the primary dredging method, such DO reductions are extremely unlikely. If they did occur, any such reductions would be localized and short term, with minimal impacts (US Navy 1990; Herrera 2022a). Even if some amount of mechanical dredging does occur, widespread anoxic conditions would not occur due to the limited duration and extent of dredging. In addition, although contaminated sediments can also be remobilized by dredging, the sediments in Capitol Lake are relatively clean and no substantial remobilization of such materials is anticipated.

Curing concrete can contribute to high pH (alkaline) conditions in the water column if the concrete source has been recently cast and not allowed adequate curing times. Where the pH effects are of a large magnitude, the pH of the water column can rise to the point where deleterious effects to fish and wildlife could occur. However, no such effects are anticipated, considering the minimal number of concrete piles (20) associated with the project and delaying installation of pre-cast concrete piles until the concrete has completely cured.

Any additional water quality effects from dredging would not have the potential to result in mortality, and any sub-lethal harm to fish would be minimal and temporary under all action alternatives. Under all action alternatives, water quality impacts from dredging on anadromous fish (including salmon) as well as resident freshwater fish would be **less-than-significant**.

Noise and Vibration

All action alternatives would create in-water noise and vibration during dredging. The noise generated by dredging would not cause lethal or sub-lethal physiological effects but could have some effects on fish behavior and movement, including avoidance (Wenger et al. 2017).

In addition, all action alternatives include the temporary placement of containment cells to create shallow water habitat areas in the Middle and North Basins. The areas would be created by placing dredged material into containment cells formed by the temporary installation of sheet piling. The sheet pile walls would be installed (and removed) using vibratory methods, with the length of sheet piling varying by alternative. The Managed Lake and Estuary Alternatives have a similar extent of sheet pile installation, while the Hybrid Alternative has about 25% less length of sheet pile.

Vibratory pile driver hammers use an oscillatory motion and heavy weight to force the pile into the substrate. They typically produce substantially lower sound levels than do impact hammers, with a slower rise time (the time for the noise wave form to rise from 10 to 90% of its highest peak) and lower sound frequencies. As a result, the pile-driving sound levels from the vibratory hammer are less intense and spread over a longer time period, thereby minimizing the potential to harm aquatic organisms (Teachout 2007). Vibratory installation of steel piles in a river in California resulted in sound pressure levels that were not measurable above the background noise created by the current (Reyff 2006). Carlson et al. (2001) studied acoustic data and salmonid response during construction of a new pier on the Oregon Coast, and found that the use of vibratory hammers for pile installation are not likely to have a significant impact on migrating salmon behavior, because infrasound produced by vibratory pile driving is short in duration and because of the relatively short range of the component of the total sound field to which salmon show an avoidance response. No mortality of fish or substantial behavioral impacts are expected to occur from the sheet pile installation.

Under all action alternatives, impacts on anadromous fish (including salmon) as well as resident freshwater fish from noise and vibration associated with both dredging and containment cell installation and removal would be **less-than-significant**.

Summary of Impacts from Initial Dredging and Creation of Habitat Areas

Overall, the potential impacts on fish from initial dredging and dredge spoil placement activities common to all action alternatives, when including associated BMPs, would vary depending on the life history and ecology of the species. Some fish, including resident freshwater fish, would likely be harmed, killed, or show behavioral changes, primarily due to entrainment during dredging. For salmon and other species that occupy the limnetic zone of open water, adverse impacts would be limited because of the fishes' abilities to avoid the construction areas. Impacts would be greater for species associated with lake bottom habitats (see Table 4.4), such as burrowing species, because of to these fishes' vulnerability to entrainment during dredging and burial during dredge material placement. However, any such impacts would be relatively minor, of temporary duration, and would not result in a large degree of mortality, when considering the entire population of any given species in the lake. As no substantial widespread impacts on any anadromous or resident fish species are anticipated, impacts from dredging and dredge disposal activities are expected to be **less-than-significant** under all of the action alternatives.

Construction of New In-water/Overwater Structures

New overwater structures constructed in all action alternatives include boardwalks in the South and Middle Basins, a new dock at Capitol Lake Interpretive Center, and a new boat ramp at Marathon Park. The in-water work associated with constructing these structures would include the placement of foundation piles or piling bents and minor grading, which would result in localized and temporary increases in turbidity and in-water noise and vibration during construction. The placement of these structures would involve a combination of pile installation techniques, including approximately 20 concrete piles installed by auguring (screwing) the piles to construct the boardwalks and a new dock at Marathon Park.

Turbidity and Sedimentation

Construction of new in-water and overwater structures would generate minor turbidity from substrate disturbance during pile installation and the use of barges. Containment systems would be used during construction to prevent debris from falling into the water. Any impacts on fish from pile installation and boardwalk construction would be both minor and temporary. For all action alternatives, impacts from turbidity and sedimentation associated with the construction of new in-water structures on anadromous fish (including salmon) as well as resident freshwater fish would be **less-than-significant.**

Noise and Vibration

No substantial impacts on fish from in-water noise from pile installation are expected from auguring or vibratory pile driving. However, the use of impact hammers can cause impacts on fish, including injury and mortality. Impact hammers use various mechanical methods to pound the piles into the substrate. These differences result in substantially different underwater sound characteristics and potential impacts on aquatic species. The risk of injury or mortality for aquatic species and fish associated with impact pile driving noise is generally related to the effects of rapid pressure changes, especially on gas-filled spaces in the body. Rapid volume changes of the swim bladder may cause it to tear, causing death or severe injury, reduce hearing sensitivity in some hearing specialist species, or cause temporary stunning and alterations in behavior (Hastings and Popper 2005).

Impact pile driving of 24-inch hollow steel piles would likely produce peak sound levels around 206 decibels (dB), which is the presumed single pile-strike injury threshold for fish (WSDOT 2020). Pile driving would also exceed the fish disturbance threshold for cumulative sound exposure level (SEL) for multiple strikes (150 dB root mean square [RMS]) and/or injury thresholds for fish (smaller than 2 grams [g], (183 dBPeak) or larger than 2 g (187 dBPeak).

The ranges of sound levels from pile driving are predicted to be much higher than the disturbance threshold for fish; however, this prediction assumes open water conditions within direct line of sight of the pile driving activity and no obstructions. When underwater sound waves encounter an obstruction, such as a land mass, they are stopped or reflected. Therefore, the relatively confined setting of the South Basin may effectively contain the sounds generated by pile-driving activities within that basin. Most fish within the North Basin could be disturbed to some degree by the pile-driving activities, and fish within the injury threshold zone could be physically harmed. These potential impacts do not take into account methods or BMPs that would minimize the sound levels or enhance the attenuation rate of the sound levels generated by the pile driving.

The project would employ BMPs developed to reduce underwater noise generated by impact pile driving. These noise attenuating devices include air bubble curtains (confined or unconfined), temporary noise attenuation piles, or air-filled fabric barriers. An air bubble curtain is a device used during pile driving that infuses the area surrounding piles with air, thereby generating a bubble screen. The purpose is to reduce peak underwater sound pressure levels (SPLs), thereby reducing potential adverse impacts on aquatic organisms. The use of such devices, properly designed and implemented, has been shown to reduce peak sound levels by a factor of from 2 to 38 dB, with most devices achieving attenuation in the range of 5 to 20 dB (WSDOT 2020). The use of such a BMP, especially in an area with relatively soft sediments, would almost certainly reduce the peak single-strike noise level to below the 206 dB injury level. Combined with the fact only seven piles would be proofed with an impact hammer, this would likely limit the number of impact strikes, limiting the potential for fish injury due to cumulative SEL exposure. The project would likely result in some negative impacts on fish due to changes in behavior; however, these impacts would not result in mortality, but rather a minor and temporary impairment to fish closest to the noise source. With the implementation of BMPs, noise impacts from pile driving on fish would be **less-than-significant** to anadromous fish (including salmon) as well as resident freshwater fish under all of the action alternatives.

Summary of Impacts on Fish from Construction of New In-water/Overwater Structures

Overall, the potential impacts on fish from the construction of new in-water and overwater structures would vary depending upon the life history and ecology of the species. For salmon and other species that occupy the limnetic zone of open water, adverse impacts from turbidity would be limited because of the fishes' abilities to avoid the construction areas, as compared to species associated with lake bottom habitats; conversely, salmon and other fish species with a swim bladder are more susceptible to damage from in-water noise. However, given the limited time, any such impacts are expected to be relatively minor, of temporary duration, and would not result in a large degree of mortality, when considering the entire population of any given species in the lake. As no substantial widespread impacts on any anadromous or resident fish species are anticipated, impacts from construction of new in-water/overwater structures on these species groups are expected to be **less-than-significant** under all of action alternatives.

5.3.1.2 Impacts on Fish from Operation (Common to All Action Alternatives)

The action alternatives have in common several operational activities that would affect fish. These activities include the maintenance dredging to manage accumulated sediment, the presence of the new habitat areas, and the operational impacts on fish of increased overwater and in-water structures associated with the boardwalks, as well as the associated artificial lighting. The adverse impacts and/or beneficial effects of these activities vary by alternative and are discussed below in Sections 5.4.2.2, 5.5.2.2, and 5.6.2.2.

5.3.2 Wildlife

5.3.2.1 Impacts on Wildlife from Construction (Common to All Action Alternatives)

Initial Dredging and Creation of Habitat Areas

Initial dredging and the related creation of habitat areas would cause temporary disturbance to water-dependent species over a 4- to 8-year period during the in-water work windows. In particular, the use of pile driving for the installation of sheet piles for the habitat areas would be disruptive to wildlife. Waterfowl would likely avoid the area during the construction period due to the loud noise and general human-caused disturbances from construction work. The in-water work window includes June through mid-August and mid-November through February each year. Thus, the disturbance would occur during summer and winter. Summer broods and wintering waterfowl would avoid the areas of construction.

Piscivorous birds such as bald eagle and great blue heron would avoid the area during construction. Raptors that currently feed in the upland areas and songbirds would not be affected by construction. Freshwater mammals, such as river otter, would likely avoid the area during the day when active work is occurring but would still use the site before or after construction commences during the early morning hours or in the evening. The sediment disturbance and associated turbidity would likely temporarily affect the production of aquatic emergent insects and reduce prey availability for bats in parts of the project area with active construction. However, substantial portions of the project area would still be available for foraging. There is some local evidence that hibernating bats may venture out on dry and calm evenings during the winter to feed, but the vast majority of their foraging occurs during the spring, summer, and early fall, concentrated during the summer when they are raising young. In-water construction would occur from June 1 to August 15 and November 15 to February 15, and is expected to cause some disruption to bat feeding. Bat activity is significantly reduced after September; therefore, work within the November 15 to February 15 work window could have less disruption to bat feeding, although most bat activity occur outside of the daytime construction hours, regardless. As a result, impacts are expected to be **less-than-significant.**

Marine benthic organisms in West Bay may experience increased turbidity and sedimentation effects during initial dredging and construction. These effects would be temporary and received in pulses associated with major dredge/construction times, and these natural systems would recover quickly. Therefore, the impact is considered **less-than significant**.

Construction of New In-water / Overwater Structures

Construction of the boardwalks and dock is expected to occur over an approximately 4- to 6-month duration and would be staged from land or water. Construction would temporarily disturb wetland and upland habitat during the construction period. This temporary disturbance is negligible and would have minimal corresponding impacts on wildlife. Wildlife that use these lake margins or wetlands in these areas would avoid these sites during construction. Species most likely affected by construction of these elements include great blue heron, waterfowl, spotted sandpiper, and some songbirds. These effects would be **less-than-significant**, limited to the construction period.

Construction Staging Areas

Construction for all action alternatives would be staged around the 5th Avenue Dam, in Marathon Park, and in Tumwater Historic Park, with some staging expected to occur on portable barges or on floats throughout the Capitol Lake Basin and upland within adjoining parks and public spaces.

These elements represent additional disturbance factors to wildlife, particularly waterfowl, that regularly use the lake for foraging and resting. These disturbances are considered **less-that-significant impacts.**

5.3.2.2 Impacts on Wildlife from Operation (Common to All Action Alternatives)

The action alternatives have in common several operational activities that would affect wildlife, including maintenance dredging, the presence of the new habitat areas, and the operational impacts of increased overwater and in-water structures. The adverse impacts and/or beneficial effects of these activities vary by alternative and are described below in Sections 5.4, 5.5, and 5.6.

5.3.3 Tribal Resources

In-water construction-related activities such as dredging, creation of habitat areas, and in-water and overwater construction would cause physical or behavioral responses in fish. These activities could also affect aquatic habitat, which could result in a minor reduction in the number of fish surviving to adulthood and returning to fishing areas, thereby affecting the number of fish available for harvest (in marine waters) by tribes. However, no impacts on tribal fishing from dredging activities are expected as all initial dredging would occur within Capitol Lake, which is currently closed to fishing. As described in Section 5.3.1.1, no substantial widespread impacts on any anadromous or resident fish species are anticipated.

5.4 MANAGED LAKE ALTERNATIVE

5.4.1 Fish

5.4.1.1 Impacts on Fish from Construction

The Managed Lake Alternative would include construction of the following:

- Non-vehicular bridge
- 5th Avenue Dam overhaul repairs

In addition to the construction activities described in *Impacts Common to All Action Alternatives*, Section 5.3.1, the Managed Lake Alternative also includes some additional impacts due to construction of the non-vehicular bridge. Construction of the bridge would result in some additional turbidity and sedimentation, as well as some noise and vibration from the installation of approximately seven 24-inch diameter steel piles driven with a combination of vibratory and impact methods to construct the bridge. However, with the implementation of BMPs as described in Section 5.3.1.1, these impacts, including noise impacts from pile driving and minor increases in turbidity, would be **less-than-significant** to anadromous fish (including salmon) as well as resident freshwater fish under the Managed Lake Alternative.

During initial dredging, there could be minor impacts on freshwater shellfish in Capitol Lake from direct disturbance and increased turbidity and associated sedimentation. These effects would be temporary and received in pulses associated with major dredge/construction times, and populations would be expected to recover over time.

Dam overhaul is necessary for the radial gates and mechanical and electrical components to maintain reliable functionality. Additional ongoing inspection and maintenance of the gates, mechanical, and electrical systems and some repair/patching of the concrete structure would likely be required during the 30-year time horizon evaluated. Specific work includes soil stabilization of the earthen portion of the dam, concrete and reinforcement repair and cathodic protection, electrical and mechanical system upgrades, and radial gate repair and reconstruction.

Most of the work associated with dam repair does not involve in-water work within either Capitol Lake or Budd Inlet. However, construction of a buttressing berm to improve stability of the earthen dam includes placement of up to 25,000 cubic yards (19,114 cubic meters) of aggregate and riprap placed along approximately 0.5 acre (0.2 hectare) of the shoreline on the downstream (West Bay) side of the earthen dam (in-water work) and adjacent to the dam along a portion of shoreline. This work, which would take approximately 4 weeks to complete, would result in some temporary turbidity and sedimentation in West Bay, which could have minor effects on aquatic life. Appropriate BMPs would be implemented for the buttressing and other dam overhaul work, such as the use of containment devices where appropriate, and all in-water work timing restrictions would be strictly adhered to. Based on these requirements, the temporary nature of the repairs, and minimal in-water work required, any impacts on fish and fish habitat for all species groups would be minor and temporary, and therefore **less-than-significant**.

5.4.1.2 Impacts on Fish from Operation

Under the Managed Lake Alternative, the Capitol Lake Basin would remain a freshwater system and remain physically separated from the marine waters of Budd Inlet. General fish distribution patterns in both the lake and within Budd Inlet would be similar to existing conditions, with lake habitat supporting those anadromous and freshwater species that currently are distributed in the lake (see Section 4.1.1). Marine fish distribution would continue to be limited to those areas of the study area downstream of the dam.

Primary operational effects of the Managed Lake Alternative would be related to alterations in aquatic habitat (specifically lake bathymetry and associated water depths), due to both initial and maintenance dredging, as well as the direct effects of the maintenance dredging. In addition, potential impacts from operation could include those from installation of habitat areas and overwater and in-water structures, as well as associated with the operation of long-term lighting, as discussed below.

Aquatic Habitat Alterations

Initial dredging would remove sediment from the North Basin while maintenance dredging would be limited to a single event in the North Basin, approximately 20 years after construction of the alternative. Because of initial dredging to a depth of -3 feet (NAVD 88), much of the North Basin would become deeper although the total wetted area in the North Basin would remain unchanged. Dredging would result in substantially more deep freshwater habitat, defined as water depths greater than 8.2 feet. The amount of deepwater habitat would increase from approximately 54 to 86 acres under the Managed Lake Alternative, as compared to existing conditions, an increase of approximately 60%.

In the Middle Basin, the placement of dredged material to form habitat areas would reduce the wetted area by approximately 30 acres. The dredged material would affect habitat at intermediate water depths (2 to 6.6 feet) with very little change in shallow (<2 feet water depth) and deeper (> 6.6 feet water depths). The South Basin would initially remain unchanged from existing conditions, both in total wetted area and water depths. In the long term, both the Middle and South Basins would have continued deposition of sediment and the margins of the basin would gradually transition to wetlands.

In addition, the dredging would result in the removal of a substantial amount of invasive aquatic vegetation, including invasive Eurasian watermilfoil. This loss of invasive and native aquatic vegetation and deepening of the channels would have a neutral to slightly beneficial effect on both water temperatures within the study area as well as on some associated water quality parameters, such as DO. Removal of aquatic vegetation during maintenance dredging would also result in minor benefits to salmon species and minor negative impacts on bottom-oriented fish and piscivorous freshwater resident predators (such as bass) that utilize such vegetation to increase feeding success.

The amount of overwater vegetation would gradually increase adjacent to the created habitat areas, providing shade and cover for fish species, including anadromous salmonids (especially juvenile coho salmon), which utilize and benefit from such habitat. Negligible changes would be expected to existing upland vegetation along the perimeter of the lake. In the long term, the channel margins in most of the Middle and South Basins would transition to wetland habitat with sporadic shallow water openings, creating a more riverine-like system in these basins than currently exists, while the thalweg of the Deschutes River would function more as a true riverine system, likely reducing the use of these areas by fish that prefer slower water, lacustrine habitat.

Overall, the alterations in aquatic habitat in the lake associated with changes in both the amount and depth of in-water habitat would result in **minor beneficial effects** for both the anadromous and freshwater species groups, although some minor reductions in the numbers of bottom-dwelling resident fish in the Middle and South Basins may occur. A proportion of coho and Chinook salmon may experience a slight benefit from the removal of aquatic vegetation in the North Basin and the development of complex edge habitat in conjunction with a more riverine-like main channel in the Middle and South Basins.

Habitat Areas

Under the Managed Lake Alternative, dredge material from initial dredging would be used to create habitat areas in the Middle Basin. The areas would be constructed to resemble natural floodplain islands, with irregular shapes and would be orientated and placed in locations that avoid erosion hotspots. The habitat areas would provide high-quality migration and rearing habitat for juvenile salmonids, due to the gradual 10:1 slopes of the constructed habitat and the presence of natural vegetative communities that would become established on the nutrient-rich lake bed sediments that comprise the habitat areas. These features would offer salmon heterogeneous, complex fresh-water habitat that could provide both cover from predators and a source of food (insect drift). Overall changes in habitat zone area throughout the study area are discussed above under *Aquatic Habitat Alterations.*

Overwater and In-water Structures

The Managed Lake Alternative includes new permanent overwater structures (OWS) and in-water structures, in the form of boardwalks, in the Middle and South Basins, and a new non-vehicular bridge in the North Basin. All overwater structure would be located in the freshwater environment. The alignments of these structures would add approximately 56,500 square feet (SF) (at summer lake level) of overwater structure, as compared to existing conditions.

Overwater structures produce shade that can have direct or indirect negative impacts on fish, while the elements that support such structures, such as piles and columns, can also have negative or positive effects on some fish species, related to changes in predation. The placement of additional permanent overwater structures can alter in-water shading intensities and patterns. Shade effectively creates a different habitat type in contrast with the adjacent open water aquatic environments that lack shade, especially in the transition between light and shade, where an edge effect can potentially influence fish behavior and habitat selection.

Shading of the water column (in-water shading) can affect aquatic habitat by reducing the growth of aquatic vegetation in shallower areas. The presence of large structures in freshwater systems, such as the SR 520 floating bridge in Lake Washington, has also been shown to delay the outmigration of juvenile salmonids (Celedonia et al. 2008a). Large overwater structures, such as ferry docks, can also disturb the composition of the marine nearshore aquatic community (vegetation and benthic organisms) by decreasing light availability, and may also negatively affect the migratory behavior of juvenile salmonids, which in turn may influence outmigration timing and survival (Nightingale and Simenstad 2001). In addition, docks and piers provide the ideal shade and overhead cover for ambush predators, with largemouth and smallmouth bass most likely to benefit from increased predation opportunities under shoreline structures (Celedonia et al. 2008b).

Effects of OWS on fish vary depending on numerous factors that influence in-water shade levels including the width of new bridge decks, the height over water of new bridge decks, light diffraction around the structures, light refraction in water, and the spatial alignment of the structures in relation to the path of the sun. The general east and west alignment of the non-vehicular bridge would produce less shade than would the boardwalks, which are generally oriented north to south. In both cases, the height of the structures above the water level would likely allow some sunlight under the structures, depending on orientation and seasonal factors.

For the Managed Lake Alternative, bass and other predatory freshwater fish (e.g., northern pikeminnow) may benefit from the increase in overwater structure through increased predation success on juvenile salmonids, which would be negatively affected. However, the potential negative impacts from shading on fish and aquatic species are likely minimal given the relatively small size of the boardwalks and non-vehicular bridge, compared to the size of the open water portion of the Capitol Lake Basin. In addition, the created habitat areas would create complex vegetated habitat that can provide cover for juvenile salmonids to avoid predation.

The presence of piles or columns in the water column can also lead to similar changes in predation as described above. However, the project would result in only a relatively small number of generally small-diameter piles installed to support the overwater structures, with approximately 290 small-diameter piles installed for the boardwalk on the west shoreline of the Middle Basin and seven piles for the non-vehicular bridge, so any effects on fish migration and predation would be minimal, with **less-than-significant impacts** on all of the species indicator groups.

Artificial Lighting

Artificial lighting would be installed to light the path of the 5th Avenue non-vehicular bridge under the Managed Lake Alternative. Currently, both the 4th Avenue and 5th Avenue vehicular bridges have lighting. Artificial lighting has the potential to affect the distribution and behavior of some fish, including salmonids. The magnitude of such effects would vary with the amount of light reaching the water surface and the expected fish use of the illuminated area. Effects would vary by species, life history stage, foraging strategy, and other physical and environmental factors (Celedonia et al. 2008b; Machesan et al. 2005). Any potentially negative impacts on fish from artificial lighting will be minimized by reducing the intensity of the light reaching the water surface through positioning the lights to illuminate only the walkways or by use of other methods, such as hoods that prevent excess light from reaching the water surface. In addition, the light intensity will be limited to the minimum amount to achieve visibility and address safety concerns. Based on the minimization measures, the artificial light is expected to have **less-than-significant impacts** on all of the species indicator groups.

Buttressing Berm

The Managed Lake Alternative would involve the placement of a buttressing berm to improve stability of the earthen dam. This berm would be created by placement of up to 25,000 cubic yards (19,115 cubic meters) of aggregate and riprap placed along approximately 0.5 acre of the shoreline on the downstream (Budd Inlet) side of the earthen dam (in-water work) and adjacent to the dam along a portion of shoreline. The displacement of current native marine sediments by rock armoring would result in a reduction in the quality of the habitat and a minor reduction in habitat functions supporting the marine species groups. Specifically, the production of benthic macroinvertebrates would be affected where the rock material displaced native sediments, however the affected area includes only a very small portion of Budd Inlet and reducing the invertebrate population in this area would be, at most, limited to individual fish and would not negatively affect fish populations or result in measurable changes to species distributions or densities. Therefore, the buttressing berm would result in **less-than-significant** impacts to marine fish species.

Maintenance Dredging

Potential impacts on fish associated with dredging for construction are described in Section 5.31 and would also apply to maintenance dredging, which would occur approximately 20 years after project construction. Note that while beyond the analysis timeframe of 30 years, maintenance dredging would occur more frequently after this initial dredge event, as the sediment storage capacity in the Middle and South Basins would be reduced over time. Maintenance dredging for the Managed Lake Alternative would occur in the freshwaters of the North Basin, with the impacts would be limited to freshwater or anadromous species in the freshwater of the North Basin. For salmon and other limnetic fish, maintenance dredging would cause **less-than-significant impacts** under the Managed Lake Alternative. The impacts would be limited to freshwater or anadromous species in the freshwater of the North Basin and very similar to those evaluated in Section 5.31 for initial dredging in the North Basin.

Disposal of dredge spoils associated with the Managed Lake Alternative would occur by using hoppers to transport dredged material from the lake to a transload facility established at a location such as Marathon Park. Dredged material would then be transferred from the barge(s) to highway legal trucks for disposal at an upland facility. As on-site disposal of spoils from maintenance dredging is not included under the Managed Lake Alternative, there would be **no impacts** on fish from dredge disposal activities.

5.4.2 Wildlife

5.4.2.1 Impacts on Wildlife from Construction

The non-vehicular bridge would be supported on piles and span from Deschutes Parkway, and tie into the existing Heritage Park pathway adjacent to 5th Avenue. Construction of the bridge would take 4 to 5 months, and in-water-work would occur during the work window. During this time, wildlife that use the north end of the lake or West Bay would likely avoid the area because of noise and increased human activity. In particular, noise from pile driving would disrupt wildlife. Waterfowl are the freshwater species group most likely affected by this construction, but they could move to other parts of the basin for foraging or resting. Once construction is complete, the waterfowl would return to using this area.

Construction activities related to repair of the 5th Avenue Dam would be similar to those described above for the non-vehicular bridge; however, no pile driving would be required and there would be less noise. Repairs of the dam would require approximately 100 days of construction over a 1-year period. BMPs would minimize these potential adverse impacts. Species groups most likely affected would be waterfowl that forage or rest on the lake near the dam. During repair activities, wildlife that use the north end of the lake or West Bay would likely avoid the area because of noise and increased human activity. Once construction is complete, the waterfowl would return to using this area. On the marine side of the dam, harbor seals may be disturbed by the construction noise and choose to use areas away from such noise. Because other areas of the lake and West Bay are available for wildlife to forage or rest in during repair activities, impacts on wildlife would be **less-than-significant**.

5.4.2.2 Impacts on Wildlife from Operation

Under the Managed Lake Alternative, the North Basin would remain open water while the Middle and South Basins would progress to a mix of vegetated wetlands and shallow water habitat over time. This transition would take place over a period of decades. The main effects of this alternative are associated with these habitat changes, and the habitat areas established in the Middle and South Basin. See the *Wetlands Discipline Report* (ESA 2022) for a more detailed description. Additionally, maintenance dredging of the North Basin would occur after approximately 20 years. Wetland vegetation would develop in shallower areas as sediment accumulates as the 20-year mark approaches.

Most of the Middle and South Basins would transition to wetland habitat as sediment accumulates, with sporadic shallow water openings (Table 5.2 lists the estimated vegetation changes). The habitat areas would be at elevations that support emergent, scrub-shrub, and forested wetlands. Additionally, ridges or hummocks on the constructed habitat would support upland vegetation, creating a wetland/upland mosaic.

Table 5.2 Estimated Acreage of Habitat Types under the Managed Lake Alternative

Habitat Type	Dominant Vegetation	Estimated Acreage[1]
Deepwater Habitat - Freshwater	Unvegetated or common waterweed, pondweed species, yellow water lily, watershield, duckweed, arrowleaf	107
Vegetated Freshwater Wetland	Willow, western red cedar, red alder, spirea, twinberry, dogwood, slough sedge, soft rush, piggyback plant m	210
Deepwater Habitat – Estuarine[2]	Aquatic vegetation	208
Estuarine Wetland and Tideflat[2]	Tufted hairgrass, meadow barley, Douglas' aster, Baltic rush, seashore saltgrass, Pacific silverweed, sea plantain, pickleweed, fleshy jaumea, Puget Sound gumweed, lakeshore sedge	4

Notes:

1. Areas are estimated based on modeled future conditions and rounded to the nearest acre and do not account for in-water or overwater structures.
2. West Bay only.

The habitat areas replace what is deepwater habitat under existing conditions. After initial construction and plant installation, the habitat areas would take several years to develop. Negligible changes are expected to existing upland vegetation along the perimeter of the lake. The habitat areas would be monitored and managed according to the prescriptions in the Habitat Enhancement Plan (as described in Section 5.7).

The following narrative describes the anticipated impacts of the Managed Lake Alternative on species groups and the associated indicator species.

Shellfish

Maintenance dredging of the North Basin would occur after approximately 20 years, removing excess sediment buildup. **No impacts** on estuarine benthic invertebrates within West Bay would be expected.

Birds

Shorebirds/Wading Birds

Development of habitat areas would offer additional foraging opportunities for great blue heron with the increase in shoreline habitat for wading. Spotted sandpiper also would make use of the margin of these habitat areas for foraging. The additional created habitat would occur around the margin of the constructed habitat areas, and would represent a **minor beneficial effect** on both species.

In the long term, the South and Middle Basins would transition to vegetated wetland habitat as these areas fill in with sediment. It is not possible to predict the exact outcome of this process, but there would likely be an increase in foraging areas for these bird species as the lake fills in, and the water becomes shallow enough for foraging for shorebirds and wading birds. The impacts of maintenance dredging in the North Basin would be comparable to initial dredging impacts described in Section 5.3.2 and would cause minor disturbances to this group. The impacts of maintenance dredging would be temporary and **less-than-significant.**

Waterfowl

Dabbling ducks would find additional foraging areas along the margin of the habitat areas in the medium term (5 years or so) before the area transitions to wetlands. Some deepwater habitat that was used by diving ducks would be replaced by the habitat areas, but this change would be negligible and the impact would be **less-than-significant**.

Similar to the effect for wading birds, as the South and Middle Basins fill in and become shallow water and wetland habitat, there would likely be more foraging habitat for dabbling ducks. Habitat would likely decrease for diving ducks, especially those that forage on fish, as the basins fill in and support fewer fish. This is considered a **less-than-significant impact** on common waterfowl species as there is no lack of freshwater pond and lake habitat in the region.

Maintenance dredging in the North Basin would cause minor disturbances to waterfowl and represent a **less-than-significant** impact.

Aerial Feeders

Violet-green swallows and other aerial feeders would be negligibly affected by the implementation of the Managed Lake Alternative, comparable to existing conditions. The slow transition from open water in the South and Middle Basins would reduce the production of emergent insects, but the riparian, transitional, and upland areas of the constructed habitat would produce other insects that offer other prey opportunities for aerial feeders. The impact on this species group would be **less-than-significant**.

Raptors

Bald eagles and osprey would experience a negligible adverse impact from the transition of deepwater habitat to wetland habitat areas. Foraging opportunities for these species would be reduced as the

South and Middle Basins transition to vegetated wetland habitat. About 100 acres of open water would remain in the North Basin for foraging for these species. Other raptors, such as Cooper's and sharp-shinned hawks, would have additional hunting opportunities for songbirds that would use the constructed habitat areas, a **minor beneficial effect.**

Songbirds

No change in the upland habitat surround the lake is anticipated under this alternative; thus, there would be **no impact** on songbirds that occur here. The habitat areas would offer additional foraging and nesting opportunities for a number of songbirds such as yellow warbler, chickadees, and wrens, a **minor beneficial effect.**

Bats

As described above, the Woodard Bay bat trestle bat colony includes approximately 3,000 Yuma myotis and little brown bats, with at least some individuals documented using Capitol Lake for foraging and/or drinking, in addition to other areas in the region including open water, riparian corridors, forested areas, and parkland (Falxa 2004, 2005, 2008). The Managed Lake Alternative would result in no substantive changes to existing conditions that are currently maintaining the constructed Capitol Lake and associated habitats; therefore, it is anticipated to result in a **less-than-significant** impact on the bats using the Woodard Bay trestle, as well as other bat species who reside in the area.

Other Water-Dependent Mammals

The loss of deepwater habitat as the South and Middle Basins transform to shallow water and vegetated wetland habitat would reduce the fish productivity of the basin and reduce the forage base of otters that currently use the lake. The potential impacts on otters would be negligible. Conversely, the habitat areas would afford resting and potentially denning sites for otters.

The Managed Lake Alternative would have **no impact** on orcas or harbor seals that use Budd Inlet.

5.4.3 Summary of Impacts – Managed Lake Alternative

Under the Managed Alternative, impacts on fish and wildlife would range from **less-than-significant** to **minor, beneficial effects**. No significant adverse impacts on fish or wildlife would occur, or on the habitats upon which they depend. Habitat zones would change, including the creation of habitat areas in the Middle Basin, and species would adapt to the altered habit conditions. In addition, the alternative would result in minor adverse impacts associated with new overwater and in-water structures as well as artificial lighting. The transition of deepwater habitat to wetland and upland habitat areas would provide a minor beneficial effect for some species, such as raptors and songbirds, with the additional foraging and nesting opportunities provided by the habitat.

Some coho and Chinook salmon may experience a slight benefit from the removal of aquatic vegetation in the North Basin and the development of complex edge habitat in conjunction with a more riverine-like main channel in the Middle and South Basins, although this benefit may be at least partially offset by an increase of overwater structure leading to slightly increased predation on these species. However, maintaining a freshwater lake system would not substantially benefit species of importance to the Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation, specifically salmon and shellfish. Impacts on salmon related to habitat changes from continued deposition of sediment in Capitol Lake would likely not measurably affect fish available for harvest. Maintenance dredging could result in impacts on tribal resources similar to those described in Section 5.3.1.1 by causing physical or behavioral responses, or by affecting aquatic habitat.

5.5 ESTUARY ALTERNATIVE

5.5.1 Fish

5.5.1.1 Impacts on Fish from Construction

In addition to construction activities described in *Impacts Common to All Action Alternatives*, Section 5.3.1, construction impacts on fish and fish habitat would primarily be associated with the following:

- 5th Avenue Dam / Bridge Removal
- Construction of a new 5th Avenue Bridge and Deschutes Parkway Realignment
- Slope Stabilization along Deschutes Parkway

Other construction activities that could temporarily affect fish and aquatic habitat, although on a much smaller scale, include replacing stormwater outfalls along Deschutes Parkway SW and the Arc of Statehood, replacing culverts at Capitol Lake Interpretive Center, and coating the concrete at the Arc of Statehood.

5th Avenue Dam Removal and New 5th Avenue Bridge Construction

The new 5th Avenue Bridge would be constructed a bit further to the south of, and parallel to the existing 5th Avenue Bridge and Dam. The new bridge would be supported by foundation piles consisting of concrete columns supported by drilled shafts. The bridge would require the installation of an estimated 16 six-foot-diameter drilled shafts. Installing drilled shafts does not create in-water noise or sound pressures that have the potential to kill or injure fish.

Once the columns are installed, the bridge would be constructed using precast concrete girders. Other elements include bridge abutments, the roadway, and installation of utilities. A small amount (compared to existing bridge footprint) of riprap scour protection would be installed to protect the new bridge abutments.

Dam removal would involve removal of the earthen portion of the dam (approximately 150 feet wide at the base and 92 feet wide at the top), as well as the existing spillway. Spillway elements that would be removed include concrete abutments, pier walls, wingwalls, a bottom slab that is supported by timber piling, and steel sheet piling cutoff walls located below the bottom slab.

The primary potential impacts on fish from dam removal are associated with in-water work, including increased turbidity as well as in-water noise. The potential biological and behavioral effects on fish of these activities are described in Section 5.3. 1. Approximately 64,000 CY of material would be removed over a footprint area of about 145,000 square feet, with a construction duration of approximately 4 to 6 weeks. To maintain water quality and reduce turbidity during removal of the earthen and structural dam components, coffercells with sealed interlocks would be installed around the earthen dam structure to control turbidity during excavation and demolition activities. The coffercells would isolate the in-water work area from fish and limit turbidity in the construction area, and would be used to remove the earthen portion of the dam, prior to being repositioned to remove the concrete spillway. Once the coffercell installation is completed (during the approved regulatory in-water work window and including fish removal), excavation and demolition work can occur within the cells, as turbid water would be isolated from Capitol Lake and Budd Inlet. Because of the use of the coffercells, the application of appropriate BMPs, and adherence to in-water work windows, impacts from turbidity on all fish species groups potentially present in the work area, including both freshwater and marine, would be negligible.

Likewise, although saw-cutting and micro-blasting would be used to remove the spillway structures, the work area would be isolated from the water column by the coffercells and appropriate BMPs and micro-blasting methods would be implemented, to eliminate waste materials entering the lake or bay, and to minimize vibration and overpressure that could harm fish. Demolition of the concrete spillway would use a combination of land- and marine- based equipment, with BMPs implemented for any marine barges or work boats, to minimize or eliminate grounding or propeller wash impacts on fish and fish habitat.

Construction of the coffercells would require the installation of sheet piles using vibratory methods. Land-based pile installation equipment, stationed on the existing dam, would take approximately 8 to 10 weeks to install the coffercells. As described in Section 5.3.1, in-water vibratory pile installation would have minimal impacts on fish.

With implementation of avoidance and minimization measures, such as containment of all overwater debris from entering the water column and minimization of the impacts from the use of work barges during bridge construction, construction of the new 5th Avenue Bridge and removal of the existing 5th Avenue Bridge and Dam would be expected to result in only temporary and minor direct impacts on fish, and would have **less-than-significant impacts** on all species groups.

Deschutes Parkway Stabilization

Under the Estuary Alternative, a 7,500-foot-long buttress would line Deschutes Parkway from Interpretive Center to the opening to Budd Inlet, and is proposed to increase the stability of the embankment. The buttress, constructed with repurposed earthen dam material and dredged sediment, would be covered in fish mix from about 5 feet above the mean higher high water (MHHW) to the toe of the buttress to provide suitable substrate material for fish. The slope would create intertidal and saltmarsh habitat along Deschutes Parkway, and the upper portions would be planted with appropriate native salt-tolerant vegetation in accordance with a Habitat Enhancement Plan (see Section 5.7, Mitigation). Although placement of the bulkhead material could temporarily increase suspended sediment and turbidity and would disrupt the existing benthos in the stabilization footprint, the limited time-scale of the work, combined with the limited magnitude of this activity, would result in **less-than-significant** impacts on fish and fish habitat for both anadromous and freshwater resident fish species groups.

Other Construction Impacts

At least 18 corrugated metal (steel) pipe (CMP) outfalls are located along Deschutes Parkway. Under the Estuary Alternative, the outboard portions of these outfalls would be replaced with a more suitable material for saltwater exposure, such as High Density Polyethylene (HDPE) or concrete, and a backwater prevention valve installed or completely replaced. Most of the associated construction work would occur in upland areas, and in-water work would be completed at a low lake level to minimize impacts.

Prior to the removal of the 5th Avenue Dam, the concrete Arc of Statehood wall structure would be treated with an epoxy coating to provide protection from saltwater deterioration. The work would be completed at a low lake level in order to access exposed concrete surfaces and, with the application of appropriate BMPs, keep all concrete cleaning and epoxy from entering Capitol Lake.

Culverts at Interpretive Center would be converted to bridges to improve hydraulic circulation at Interpretive Center as the park transitions to saltwater wetlands. Following culvert removal, the area would be actively planted to aid in the transition to saltwater wetlands in accordance with a Habitat Enhancement Plan (see Section 5.7, *Mitigation*).

For all these activities, the limited disturbance area, adherence to in-water work windows, and the use of appropriate BMPs indicate that impacts on fish and fish habitat would be **less-than-significant** for both anadromous and freshwater resident fish species groups.

5.5.1.2 Impacts on Fish from Operation

The primary operational effect of the Estuary Alternative would be related to alterations in aquatic habitat (specifically the entry of saltwater into the basin and alterations in bathymetry), due to both initial and maintenance dredging and the 5th Avenue Dam removal.

Under the Estuary Alternative, the removal of the 5th Avenue Dam would allow saltwater from Budd Inlet to enter the Capitol Lake Basin, transforming fresh deepwater and wetland habitat to estuarine habitat. The primary impacts on fish associated with the operation of the Estuary Alternative are related to the physical and chemical transition of the freshwater lake habitats to saltwater estuary habitat, as well as the availability and types of wetland/aquatic vegetation habitat areas in the Middle Basin. The transition from a lake to an estuary would result in changes in salinity, water temperature, water quality, sediment deposition patterns, aquatic plants, and invasive species distribution. Water quality in Budd Inlet is not expected to worsen compared to existing conditions, and DO in Budd Inlet may improve slightly under the Estuary Alternative. Due to the influence of water from Budd Inlet entering the Capitol Lake Basin, water quality in the basin would change with the transition from a freshwater system to a saltwater estuary. This could include a slight decrease in DO compared to existing freshwater DO conditions, and potential for (marine) algae blooms. Any such changes are not expected to impact fish. Temperatures in the estuary may increase slightly from existing conditions due to the influence of saltwater at high tide cycles, but any such changes would be well within the tolerances for marine species.

The removal of the dam would also improve migration conditions for anadromous fish. Although migration occurs under existing conditions and is not precluded, upstream passage of juvenile fish under existing conditions may be impeded. Removal of the dam would restore natural conditions, including a gradual transition from saltwater to freshwater, and vice-versa, which would benefit anadromous salmon. In addition, removal of the dam would remove a known compression point at the outlet of the 5th Avenue Dam. Under current conditions, anadromous fish must enter and exit the lake through a small fish ladder, exposing fish to predation from marine mammal, avian, and piscivorous fish predators that may congregate at the existing bottleneck created at the dam outlet. Anecdotal information indicates that harbor seals have been observed following salmon up and into the fish ladder (Steltzner, 2021 pers. comm.). This constriction, currently the largest bottleneck in the system, would be removed under the Estuary Alternative and allow outmigrating fish, including juvenile salmonids, to exit Capitol Lake through an outlet measuring up to 500-feet-wide (at high tide) versus an outlet measuring only 9.5-feet-wide under existing conditions. Existing levels of predation from marine mammals and avian species should decrease substantially with the removal of the dam/fish ladder compression point.

The habitat areas would provide vegetated wetland habitat with some upland habitat and replace what is deepwater habitat under existing conditions. After initial construction and plant installation, the habitat areas would take several years to develop. Negligible changes are expected to existing upland vegetation along the perimeter of the lake. The habitat areas would be monitored and managed according to the prescriptions in the Habitat Enhancement Plan (as described in Section 5.7). Additionally, potential impacts from alterations in overwater and in-water structures and lighting are discussed below.

Aquatic Habitat Alterations

The removal of the 5th Avenue Dam, and resulting re-establishment of estuarine habitat conditions would affect fish through changes in salinity, and in the type and amount of aquatic habitat available. After the dam is removed, salinity in the Capitol Lake Basin at medium (average) flow conditions is expected to be in the following ranges for each lake basin under the Estuary Alternative, with salinity farther upstream of the new 5th Avenue Bridge alignment:

- North Basin – 24 to 18 parts per thousand (ppt)
- Middle Basin – 18 to 5 ppt
- Percival Cove – 14 ppt
- South Basin – 5 to near 0 ppt (at base of Tumwater Falls)

The numbers would also vary based on tidal and flow conditions, with greater salinities at high tides and low streamflows and higher salinities at low tide and high streamflow. These salinities are well within the range of a study of Puget Sound reference estuaries by the U.S. Geological Survey (USGS), which found reference salinity values ranging from 1 to 28 ppt (George et al. 2006). Estuarine conditions are usually considered to occur at 0.5 ppt and 29 ppt, and salinity in southern Puget Sound can reach as high as 32 ppt.

The re-establishment of estuarine conditions and resultant salinity changes in the Capitol Lake Basin would have immediate effects on freshwater fish present under existing conditions. For juvenile salmon originating in the Deschutes River or Percival Creek, as well as adult salmon returning to those systems, the Estuary Alternative would provide a natural freshwater to saltwater salinity gradient that is physiologically favorable (Groot and Margolis 1991).

In addition to altered salinity levels, changes in the type of habitat within the current lake basin would also occur under the Estuary Alternative. For salmon, other anadromous species, and marine fishes, the removal of the 5th Avenue Dam and estuarine conditions would provide access to a suitable marine and estuarine habitat of approximately 275 acres (at MHHW), where none currently exists, including sub-tidal, intertidal tideflat, low marsh, and high marsh habitats. At high tides, the extent of deeper water habitats (>8.2 feet deep) would increase by approximately 44 acres as compared to existing depths in the Capitol Lake Basin, with almost all of the increases occurring in the North and Middle Basins. The estuarine habitat that is fully exposed to tidal exchange would provide productive habitat for salmon, other anadromous species, and marine fishes in the area. The North Basin's extensive shallow water habitats with saltmarsh vegetation along the water's edge would provide preferred rearing habitat for juvenile salmon (Fresh 2006) and productive epibenthic and terrestrial origin prey for juvenile salmon. Habitat quality would improve over time as macroinvertebrate populations and saltwater-tolerant aquatic vegetation become established in the intertidal tideflat and marsh habitat areas.

Estuaries provide key habitat for Chinook salmon (Garono et al. 2006; Mitsch and Gosselink 2015) and support key ecological processes such as freshwater input, sediment transport, erosion and accretion of sediments, tidal flow, tidal channel formation and maintenance, distributary channel migration, movement of aquatic organisms, and detritus import and export (Schlenger et al. 2011). A wide body of literature shows the key role that estuaries in the Pacific Northwest play in supporting the growth and survival of juvenile salmonids, including Chinook salmon. Estuaries provide habitat conditions that support juvenile salmon in their physiological transitions, provide refugia from predators, and provide elevated prey resources relative to freshwater and marine systems (Simenstad et al. 1982; Thorpe 1994; Magnusson and Hilborn 2003; Price and Schreck 2003; Campbell et al. 2017; Sharpe et al. 2019; Chalifour et al. 2020). In addition, estuarine habitat serves to decrease predation risk to small and young fish by providing refuge to juvenile fish from turbid waters and nearshore habitat complexity (Simenstad et al. 1982; St. John et al. 1992; Gregory 1994; Gregory and Levings 1998; Bottom et al. 2005). This refugia serves to decrease predation risk to small and young fishes (Heck et al. 2000; Alofs and Polivka 2004). In general, the South Sound has experienced severe reductions in both the quantity and quality of such key estuarine habitats for fish (Simenstad et al. 2011).

In addition to providing habitat for outmigrating fish from in-basin, estuaries have been shown to support non-natal Chinook salmon juveniles, both hatchery and wild origin fish (Beamer et al. 2013). For example, studies in the Nisqually River estuary (the closest adjacent estuary to the east of Capitol Lake) showed that juvenile hatchery Chinook originating from other watersheds accounted for 90% of all Chinook captured. These fish originated from nine Puget Sound rivers and 14 hatcheries, located as far away as 130 km from the Nisqually River. In addition, juvenile salmon originating from hatcheries as far north in Puget Sound as the Wallace River, a tributary to the Skykomish River, have been detected in the South Sound, including within Budd Inlet (Steltzner, 2021 pers. comm.). Although the abundance of juvenile fish from other basins that would utilize Capitol Lake under the Estuary Alternative is unknown (and is likely significantly less than in the Nisqually River estuary, based on the relative sizes of the systems), some number of both hatchery and wild non-natal juvenile Chinook salmon would be expected to utilize the estuary habitats for feeding, growth, and avoidance of predators.

The portion of the study area in Budd Inlet would also experience changes in habitat, with increased deposition of Deschutes River sediments and a return to sediment transport and deposition patterns that occurred prior to dam installation. This could result in some slight benefits to marine species and anadromous salmon, as nutrient-rich sediments may support higher concentrations or more diversity of marine benthic macroinvertebrates, potentially providing increased feeding opportunities for these species groups.

For salmon, other anadromous species, and marine fishes, the estuary conditions in the Estuary Alternative would result in **substantial beneficial effects**, including to ESA-listed Chinook salmon and other salmon species spawned in other river basins that may use the estuary for feeding. Conversely, the brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, that would result from the Estuary Alternative would not be suitable for freshwater fish species, resulting in mortality to these species and constituting a **significant impact** on the native species within group, although in some cases (e.g., bass, carp, and bullhead) the affected species are non-native species that prey on native species, such as salmonids. For those species, conversion of the lake to estuarine habitat would be **less-than-significant**.

Maintenance Dredging

The Estuary Alternatives assumes semi-frequent maintenance dredging (every 6 years following project construction) in the marine environment and a greater volume of material removal over time, compared to the Managed Lake Alternative. The location of the maintenance dredging for the Estuary Alternative would occur on the east side of West Bay, in affected areas within the Port and Turning Basin, the Olympia Yacht Club, and private marinas. For the Estuary and Hybrid Alternatives, maintenance dredging would affect marine or anadromous fish species but not resident freshwater species, as no such species would be present in the marine waters of West Bay. For species associated with bottom habitats, including burrowing species, a greater magnitude of lethal and sub-lethal impacts is anticipated, due to the fishes' vulnerability to entrainment during maintenance dredging. However, no significant adverse impacts are anticipated from dredging, based on the significance criteria and the limited scope, scale, and timing of the maintenance dredging.

The Estuary Alternative would re-establish sediment transport and deposition patterns from the Deschutes River and Percival Creek watersheds into and through the estuary. The Deschutes River delivers substantial volumes of sediment to the area each year. These sediments would deposit in the estuary and over time continue to get moved downstream into lower Budd Inlet, with deposition primarily occurring along the east shoreline of West Bay, the location of several marinas and other water-dependent businesses. The river-origin sediments would deposit on top of the substrates in quantities that would require maintenance dredging as described in Section 1.0.

Maintenance dredging for the Estuary Alternative would not result in any impacts on freshwater fish, as these marine areas do not support such species. Impacts on salmon and other marine or anadromous fish associated with direct entrainment and sediment and turbidity would cause **less-than-significant impacts**, although some fish may experience harm or mortality. For marine species associated with the bottom habitats, including burrowing species in the benthic zone, impacts would be greater than for fish that utilize open water or deeper benthic habitats, due to less vulnerability to entrainment during maintenance dredging, but as the dredging effects would be temporary and only occur over a small area at a given time, impacts would still be **less-than-significant** for this species group.

If material from maintenance dredging is to be disposed of upland, the project would establish transloading facilities at the Port of Olympia or other deepwater marine accessible site. Dredge material would be loaded into highway legal trucks to dispose of material at an upland licensed disposal facility. If dredged material are to be disposed of at an unconfined open water dredged material disposal site, the split hull scows would be used to dispose of material at a permitted deepwater site in Puget Sound, the Anderson-Ketron Island Disposal Site. Although disposal of dredged materials in the open water may have minor deleterious effects on fish and aquatic life due to temporary turbidity, the in-water methods would have **less-than-significant** impacts on all species group, while upland disposal would have no impacts.

Habitat Areas

Under the Estuary Alternative, dredge spoils from initial construction would have been used to create wetland habitat areas in the Middle Basin. The habitat areas would be constructed with zones including upland, transition vegetated wetland, high marsh wetlands, low marsh wetlands, and sub-tidal habitats, depending on tides.

The constructed habitat areas would provide high-quality migration and rearing habitat for juvenile salmonids, due to the gradual 10:1 slopes of the constructed habitat and the presence of natural vegetative communities that would become established on the nutrient-rich lake bed sediments that comprise the habitat areas. These features would offer salmon heterogeneous, complex habitat that could provide both cover from predators and a source of food (insect drift) in an estuarine setting. Changes in bathymetry from habitat island creation is discussed above under *Aquatic Habitat Alterations*.

Overwater and In-water Structures

The Estuary Alternative includes new permanent OWS and in-water structures, in the form of boardwalks, supported by piles, in the Middle and South Basins, and a new 5th Avenue Bridge in the

North Basin, with all new structures located over and in estuarine habitats. The structures would add approximately 100,000 SF of overwater structure at MHHW, as compared to existing conditions. In addition, the Estuary Alternative would include the placement of large riprap or cobble material along critical infrastructure elements such as the 4th Avenue Bridge, the I-5 Bridge, and the existing railroad bridge. The placement of this material is needed for scour protection to moderate high water velocities during large storm events in an area with the potential for increased current flow from reintroduced tidal hydrology. The potential adverse impacts of overwater and in-water structures on fish is discussed in Section 5.4.1.2

Although overwater structure would increase under the Estuary Alternative, this would be offset by a substantial net decrease of in-water structure, resulting from the removal of approximately 145,000 SF of fill associated with the 5th Avenue Dam. A net reduction of approximately 142,800 SF of overwater/in-water structure would result in a net benefit to marine and anadromous fish by increasing available benthic habitat by over 3 acres and by removing in-water structures that can negatively affect fish through shading and by enhancing predator habitat (see Section 5.4.1.2). The physical footprint of the dam removal would have **moderate beneficial effects** for salmon and marine fish species expected to use the estuary, but would not benefit freshwater resident fish, which would be absent in the estuary.

Artificial Lighting

Artificial lighting would be installed to light the path of the new 5th Avenue Bridge under the Estuary Alternative. As discussed under the Managed Lake Alternative in Section 5.4.1.2 any potentially negative impacts on fish will be minimized or eliminated through lighting design and placement. Based on the minimization measures, the artificial light is expected to have **less-than-significant impacts** on all of the species indicator groups.

Temporary Relocation of In-water Structures to Facilitate Maintenance Dredging

Maintenance dredging would occur in West Bay under the Estuary Alternative. These dredging events would require the temporary removal or relocation of boat storage facilities, including at the Olympia Yacht Club and several marinas, in order the access the substrate requiring dredging. For each dredge event, this includes the temporary removal and storage of up to 100 piles (estimated) that support existing boat moorage and boat houses. The piles would be removed using vibratory methods (potentially using a combination of barge-based and land-based construction equipment), temporarily stored on barges or in the upland, then reinstalled in similar locations once the dredging event is complete, again using vibratory pile installation methods. Similarly, derrick barges, flat deck barges, and land equipment would be used to pull floats from the dredge work area and temporarily store them either at other locations in the marinas or within Budd Inlet, prior to reinstallation of the marina structures once dredging activities are complete.

The temporary removal of these structures would result in some amount of turbidity and in-water noise and vibration, which in turn can result in negative effects on fish. However, the magnitude of any effects are similar to the case for initial dredging and for the installation of piles associated with boardwalks (Section 5.3.1.1). Based on the limited nature of the disturbance, the adherence to regulatory in-water work windows, and the implementation of BMPs, the relocation of piles and floats prior to maintenance dredging are expected to have minor negative effects, that are considered **less-than-significant** on the marine and anadromous fish that may be present in Budd Inlet.

Sediment and Water Quality

As presented in the *Hydrodynamics and Sediment Transport Discipline Report* (Moffatt & Nichol 2022), the predominant direction of long-term sediment movement in the Estuary Alternative would be from the constructed estuary to the West Bay of Budd Inlet. If minor amounts of sediment are suspended and washed into Capitol Lake Basin from West Bay by high waves and strong currents during flood tides, those would be the surface sediments that have been transported downstream from the Deschutes River, which are good quality and similar to those in the Capitol Lake Basin. Therefore, **no adverse impacts** on marine and anadromous fish from exposure to contaminated sediment would be expected from minor amounts of West Bay sediments deposited in the constructed estuary during flood tides. Deschutes River flows would deposit clean sediments over the existing contaminated sediments in Budd Inlet, minimizing the future exposure of fish and benthic invertebrates that serve as fish prey to these contaminants.

Under the Estuary Alternative, the existing lake basin would become part of the estuary. The quality of the water in the lake basin would vary widely depending on the tide. During very low tides, the river would be unimpeded and flow through a defined channel that would form through the tideflats and habitat areas in the Middle and North Basins. During these very low tides, water in the main channel would reflect Deschutes River water quality: plentiful DO and little algae. During higher tides, water in the lake basin would reflect somewhat worse conditions than the water that currently exists in West Bay during lower tides. It would have lower DO and higher concentrations of algae during the critical summer and fall time period. During higher tides, the water in the basin would have adequate DO but would likely continue to have visual algae blooms (Herrera 2022a). Although the Estuary Alternative would result in some negative impacts on water quality in the lake basin based on DO concentrations at different tidal elevations and expected algae blooms, the conditions would be similar to conditions in other Puget Sound Inlets. These changes may have minor impacts on salmon and marine fish, although any such changes are not expected to result in mortality or result in major disruptions to feeding or migration. Overall, impacts on water quality are expected to be **less-than-significant**.

Aquatic Invasive Species Reductions

The transition from freshwater to saltwater would impact aquatic invasive species, which would influence fish through changes to habitat and changes to competition/predation conditions. Aquatic invasive plant species that are intolerant to saltwater would be largely eradicated from the area. Only purple loosestrife is tolerant of saltwater and thus would not be eradicated when saltwater enters the Capitol Lake Basin after dam removal. Other species (e.g., New Zealand Mudsnail, Eurasian watermilfoil, curly pondweed) have low to no tolerance to brackish water and would likely be eliminated in the North and Middle Basins, but these species may survive the lower salinities expected in the South Basin, Percival Cove, and the Interpretive Center ponds. This would likely have **moderate**

beneficial effects to anadromous and marine fish by creating room for native salt-tolerant vegetation to establish or naturally unvegetated tideflats depending on elevations relative to the tides.

The six non-native fish species that are present in Capitol Lake are somewhat tolerant of the brackish water in estuaries, but they would not be expected to maintain viable populations in the estuary or other freshwater habitats along the Puget Sound shoreline. Each species is a competitor and/or major predator of juvenile salmon; therefore, effects on these species would be **less-than-significant**. The loss of the non-native predatory fish would have **substantial beneficial effects** for salmon and most other native fish species expected to use the estuary.

5.5.2 Wildlife

5.5.2.1 Impacts on Wildlife from Construction

In addition to construction activities described in *Impacts Common to All Action Alternatives*, Section 5.3.2, construction impacts on wildlife and wildlife habitat would primarily be associated with the following:

- 5th Avenue Dam / Bridge removal
- Construction of a new 5th Avenue Bridge and Deschutes Parkway Realignment
- Slope stabilization along Deschutes Parkway

Other construction activities that could temporarily affect fish and aquatic habitat, although on a much smaller scale, include replacing stormwater outfalls along Deschutes Parkway SW and the Arc of Statehood, replacing culverts at Capitol Lake Interpretive Center, and coating the concrete at the Arc of Statehood.

These disturbances would cause wildlife that use these parts of the Capitol Lake Basin to avoid areas of active construction. Diving and dabbling ducks would be most affected as they regularly use the deepwater and lake margin habitat. This is considered a **less-than-significant** impact because it would not reduce the regional population of these common species, and foraging habitat is not limited and available elsewhere for these relatively common species. Effects from the conversion from a lake to an estuary are described under operation impacts below.

Other species that use the lake – bald eagle, osprey, and river otter – would also avoid the area during active construction. River otter would continue to use the area in the evening when construction was not occurring. The adverse impacts are considered **less-than-significant**.

Songbirds that use the upland and riparian habitat adjacent to the lake would avoid areas of active construction such as along Deschutes Parkway, considered a **negligible and temporary adverse impact.** There would be minimal impacts from replacing culverts at Capitol Lake Interpretive Center to wildlife in general; this is a relatively small construction project that would occur over the course of several weeks.

Harbor seals that use the West Bay at higher tides close to the dam and bridge would also avoid the area during the construction period. This is a **less-than-significant impact**. There would be **no impact** on orcas from construction.

Several trees with a mixed forested area would need to be removed to construct the embankment for the realigned Deschutes Parkway. Trees would be surveyed as part of design and permitting of the selected alternative and any trees that would be removed would be replaced in accordance with City of Olympia's tree protection ordinance.

5.5.2.2 Impacts on Wildlife from Operation

Under this alternative, the removal of the 5th Avenue Dam would reintroduce tidal hydrology and change the freshwater lake to an estuary system. The vegetation communities would change from freshwater to estuarine communities, similar to historic conditions. Table 5.3 shows the anticipated habitat types and areas. Additionally, there would be impacts from the maintenance dredging in West Bay. These vegetation changes would have corresponding impacts on wildlife that use the basin, as described below. The habitat areas would provide vegetated wetland habitat with some upland habitat and replace what is deepwater habitat under existing conditions. After initial construction and plant installation, the habitat areas would take several years to develop. Negligible changes are expected to existing upland vegetation along the perimeter of the lake. The habitat areas would be monitored and managed according to the prescriptions in the Habitat Enhancement Plan (as described in Section 5.7).

Table 5.3 Estimated Acreage of Habitat Types under the Estuary Alternative

Habitat Type	Dominant Vegetation	Estimated Acreage[1]
Subtidal/Deepwater Habitat – Estuarine	Aquatic vegetation	245
Tideflat	--	152
Low Marsh – Estuarine	Pickleweed, fleshy jaumea	39
High Marsh – Estuarine	Tufted hairgrass, meadow barley, Douglas' aster, Baltic rush, seashore saltgrass, Pacific silverweed, sea plantain, pickleweed, fleshy jaumea, Puget Sound gumweed, lakeshore sedge	49
Vegetated Wetland - Transitional	Sitka spruce, shore pine, Hooker's willow, oceanspray	31
Vegetated Freshwater Wetland	Willow, western red cedar, red alder, spirea, twinberry, dogwood, slough sedge, soft rush, piggyback plant	9

Notes:

1. Areas are estimated based on modeled future conditions and rounded to the nearest acre and do not account for in-water or overwater structures.

Shellfish

Changes in salinity, vegetation composition, water surface elevations, and water velocities would negatively affect the survival of freshwater mussel (*A. oregonensis*) (Nedeau et al. 2009*).* While some impacts on *A. oregonensis* in the project area would occur, the impacts would not put the overall population at risk since this species is not a state- or federally listed threatened or endangered species and is considered "Least Concern" on the International Union for Conservation of Nature (IUCN) Red List. Therefore, impacts would be **less-than-significant**.

Restoration of the basin to a functional estuary would provide a beneficial effect through a substantial increase in habitat for a variety of estuarine benthic invertebrates such as Olympia oyster; green crab; little neck, butter, and horse clams; mussels; and moon snails.

Distribution of these species within the newly formed estuary would depend on the micro-topography, occurrence of pools, and duration of intertidal periods for specific reaches of the basin. In general, oysters and clams are more likely found in the lower area of the basin and would be slow to colonize the basin. More mobile crabs would likely populate suitable regions (that meet their life history requirements) of the basin sooner. These represent **moderate beneficial effects**.

Maintenance dredging in Budd Inlet would occur approximately every 6 years. Dredging would mobilize sediments, temporarily decrease water quality, and remove benthic invertebrates that use the sediment. These impacts are considered **less-than-significant** because of the limited discrete areas where they would occur, the temporary nature of the event, and their limited scope.

Birds

Shorebirds/Wading Birds

Most shorebirds are versatile and would forage along the shoreline or in shallow water in both freshwater and estuarine habitats. The change in foraging opportunities in the estuary would be on the types of prey available and the spatial/temporal changes due to tidal fluctuation.

Herons are versatile feeders and would forage on fish and benthic invertebrates on the extensive tideflats and within shallow water at medium and low tide levels. This would provide a long-term **substantial beneficial effect** for this species group as estuarine vegetation develops and the estuarine basin becomes increasingly functional, supporting a variety of benthic organisms and fish species. The available habitat would be more extensive and dynamic, providing a variety of water depths for foraging corresponding to daily tidal fluctuations.

Shorebirds and wading birds that use low tide tideflats would temporarily avoid areas in West Bay during maintenance dredging. This is a **less-than-significant** impact.

Waterfowl

Similar to the effect on wading birds, dabbling ducks and diving ducks are able to forage in freshwater and estuarine habitat. Common goldeneye would feed on crayfish, crabs, shrimp, small fish, and snails, among other items. The estuary would provide **moderate beneficial effects** as the system becomes more diverse and the range of foraging opportunities increases. Goldeneye would key into tidal fluctuations and forage in the basin at medium and high tides when diving is optimal. These daily tide cycles would provide dynamic variation in water depths and increased opportunities for foraging over the basin.

Dabbling ducks, such as American wigeon, would sift through shallow areas and in mud for small crustaceans and mollusks. Wigeon would also feed on estuarine vegetation and in nearby grassy areas. Wigeon would feed in most areas of the basin, depending on the water depth and the occurrence of prey items.

The habitat islands created under the Estuary Alternative would provide nesting sites that are not currently present under existing conditions, and would benefit species that breed in the area such as Canada geese and American coots, which are both common species.

Aerial Feeders

Violet-green swallows and other aerial feeders may find less prey available as the existing freshwater environment may support a greater density of emergent insects than would the estuary / wetland / riparian combination. However, prey species may be diversified because of the Estuary Alternative, and these swallows are versatile and forage on a wide range of flying insects, including those that are supported by non-lentic habitat. Thus, while there may be a minor reduction in the amount of prey for these birds, any reduction would result in a **less-than-significant** impact because of their ability to prey-switch and adjust to changes from the newly restored conditions.

Raptors

There would be **no impact** on bald eagles and osprey from the transition of the basin from a freshwater lake to a functional estuary. The type of fish supported by the estuary would shift to estuarine species. Bald eagles and osprey are adept at feeding in both freshwater and estuarine environments. Freshwater ponds and lakes are not a dwindling resource in the region as compared to estuary habitat, which has been developed over the centuries in Puget Sound (USGS 2006). The estuary would provide additional habitat for juvenile salmon and may contribute to increased adult production, which are a food source for these predatory birds.

Songbirds

There would be negligible effects to the terrestrial habitat surround the lake. Some trees on the margin may succumb to the saltwater effects of the water table, but these effects would be minor and would have negligible impacts on songbirds. Yellow warbler, the indicator species for songbirds, would find additional habitat in the riparian and upland habitat formed in the Middle Basin. This additional habitat would be a **minor beneficial effect** for this species group.

Bats

As described above, there is limited evidence that bats roosting at the Woodard Bay trestle, or other bats in the region, rely only on Capitol Lake for foraging and/or drinking (Towanda and Falxa 2007; Falxa 2004, 2005, 2008; Hayes et al. 2008; Cascadia Research Collective 2011; Tobin 2020). Most of these bat species, including Yuma myotis and little brown bat, are documented as being habitat generalists, foraging generalists, and having capacity to prey-switch opportunistically (Brigham et al. 1992; Whitaker 1996; BCI 2022; WDFW 2022c,d). Because few scientific studies have documented use of Capitol Lake by bat species in the region, a conservative analysis of potential impacts is consistent with the rules for SEPA analysis.

Under the Estuary Alternative, habitats would be substantially diversified, and habitat areas would be created across the riparian zone, becoming much larger than what is currently present. The addition of estuarine wetland and edge zones between habitat patches would likely increase the diversity of invertebrates over existing conditions. Extensive study has shown that a diversity of bat species, including *Myotis* species, not only utilize estuarine, coastal, and riparian areas for foraging, but thrive in them (Brigham et al. 1992; Whitaker 1996; Ahlen et al. 2009; Gonsalves et al. 2012, 2013; Ancillotto et al. 2014; BSG Ecology 2015; Fletcher 2017; BCI 2022; WDFW 2022c,d), as long as vegetation remains relatively open for foraging (Gonsalves et al. 2012, 2013). Although the prey assemblage for bats in these habitats has not been well documented, it may be assumed that enough preferred invertebrates occur to support these bat species, including *Myotis* bats in the Northwest (Brigham et al. 1992; Burles and Nagorsen 2003; Hayes and Wiles 2013). What is not well understood is how existing ecological conditions supporting bats would compare to those replaced by the Estuary Alternative, and whether this shift would support bats as they currently occur in the region.

The effect on bats from the conversion of an artificial, lentic, open water habitat to natural riparian, wetland, and estuarine habitats is unknown. However, because of the lack of scientific information on this topic, it remains possible that existing bats may be adversely impacted. For this reason alone, it has been determined that conversion of habitats from current conditions to those resulting from the Estuary Alternative would have potentially **significant impacts** on Yuma myotis and little brown bats at the Woodard Bay trestle colony given their use of Capitol Lake for foraging and/or drinking. No impact is expected for any other bat species.

Other Water-Dependent Mammals

River otters forage in both freshwater and estuarine environments. In estuaries, they prey upon fish, crustaceans, and mollusks. Otters are known to forage along low tide tideflats in search of crabs and other invertebrates. The constructed habitat areas may offer potential den sites for river otters. Overall, there would be a change in the habitat type and prey items available for otter, but this is considered a neutral effect.

The Estuary Alternative would enhance the salmon production of the basin by providing additional refuge habitat for juvenile salmon and would increase the estuarine benthic organism prey for salmon. Overall, this would have a corresponding **minor beneficial effect** for orcas that may occasionally visit Budd Inlet.

Harbor seals would experience an increase in the area for feeding/resting when the basin is at mean and high tides. There would be a corresponding increase in the occurrence and density of prey items for seals. In addition, the habitat areas in the Middle Basin may offer safe resting spots for harbor seals at high tide.

River otters and harbors seals would likely avoid areas where maintenance dredging occurs. This is a temporary impact that is considered **less-than-significant.**

5.5.3 Summary of Impacts – Estuary Alternative

Under the Estuary Alternative, impacts on fish and wildlife would range from **beneficial** to **less-than-significant** to **significant**. Some habitat zones would change, and species would adapt to the altered habit conditions. The estuary conditions created under the alternative would result in **substantial beneficial effects** for salmon, other anadromous species, and marine fishes. Freshwater ponds and lakes are not a dwindling resource in the region as compared to estuary habitat, which has been developed over the centuries in Puget Sound. In addition, the physical footprint of the dam removal would have **moderate beneficial effects** for salmon and other fish species expected to use the estuary. Conversely, the brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, that would result from the Estuary Alternative would not be suitable for freshwater fish species, resulting in mortality to these species and constituting a **significant impact** on the native species within this group. However, some of the affected species (e.g., bass, carp, and bullhead) are non-native species that prey on native species.

For wildlife species, the change to an estuarine environment would be a potentially **significant impact** on Yuma myotis and little brown bats at the Woodard Bay trestle colony.

The conversion of deepwater habitat to wetland habitat areas would provide a **minor beneficial effect** for some species, such as raptors and songbirds.

Reintroducing tidal hydrology to the entire lake area would benefit many of the species of importance to the Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation, specifically salmon and shellfish, and potentially other fish and wildlife, as well as plants. As described in Section 5.5.1.2, the estuary conditions that would be reestablished under the Estuary Alternative would result in substantial beneficial effects, including to Chinook salmon and other salmon species spawned in other river basins that may use the estuary for feeding. There would also be a net decrease of in-water structure from the removal of fill associated with the 5th Avenue Dam, which would increase available habitat and reduce negative effects of in-water structures on salmon. Reestablishment of a functional estuary would also increase habitat for a variety of shellfish. As described in Section 5.5.2.2, by enhancing the salmon production of the basin by providing additional refuge habitat for juvenile salmon and increasing the estuarine benthic organism prey for salmon, there would be a corresponding **minor beneficial effect** for orcas that may occasionally visit Budd Inlet.

Maintenance dredging could result in impacts on tribal resources similar to those described in Section 5.3.1.1 by causing physical or behavioral responses, or by affecting aquatic habitat, and potentially affecting access to fishing areas within West Bay during maintenance dredging cycles.

5.6 HYBRID ALTERNATIVE

5.6.1 Fish

5.6.1.1 Impacts on Fish from Construction

Construction impacts on fish and fish habitat under the Hybrid Alternative are nearly identical to those described for the Estuary Alternative, including effects from turbidity and in-water noise associated with the 5th Avenue Dam removal, new 5th Avenue Bridge construction, Deschutes Parkway stabilization, and other minor construction elements (see Section 5.5.1.1). However, construction of a 2,600-foot-long sheet pile barrier wall to create a reflecting pool would create additional in-water noise and vibration impacts associated with sheet pile installation and could potentially lead to some entrapment of fish within the reflecting pool.

The reflecting pool barrier wall would also require the construction of approximately 130 sheet pile tail walls to support the barrier wall. The sheet piling for the structure would be installed using a barge-based vibratory hammer and be constructed prior to dam removal to provide a consistent water level for the barge. As described in Section 5.3.1.1, vibratory pile impacts on fish would be relatively small, and have not been shown to result in mortality or injury. Although the wall installation would take approximately 15 months of work over three in-water work windows, the in-water noise levels from vibratory pile driving would not have a significant adverse impact on fish. However, thorough geotechnical investigations have not yet been conducted and it is likely that site conditions would require the use of an impact hammer to drive at least some of the sheet piles, which serves as a load-bearing structure. As previously described, impact pile driving produces in-water noise levels that can negatively impact fish, including lethal and sub-lethal effects. Although the sound levels from impact installation of sheet piles is somewhat less than large-diameter steel piles, monitoring of previous sheet pile installations has shown that sound levels at, or near, the 206 dB injury threshold (WSDOT 2020). The use of impact driving would increase the magnitude of negative impacts on fish; however, the use of noise attenuation devices (e.g., bubble curtains) and adherence to the in-water work timing requirement would result in **less-than-significant** impacts on fish and fish habitat for any anadromous and freshwater resident fish species present during construction.

The reflecting pool would be constructed while the 5th Avenue Dam is still operational. The majority of the reflecting pool walls would be constructed, then prior to the area being completely isolated from the remainder of the lake, fish would be removed within the reflecting pool to the extent practicable. This construction approach reduces the primary potential impact related to the possible entrapment of juvenile salmonids within the newly constructed pool. To minimize possible entrapment, fish would be relocated outside of the reflecting pool and into the larger lake system. This work would occur during the approved in-water work windows, during a time when outmigrating juvenile salmon are least likely to occur in the project area. Although a few salmonids may be permanently trapped in the reflecting pool, numbers would be relatively small. Any effects from the Hybrid Alternative from entrapment of fish within the reflecting pool would result in **less-than-significant** impacts for any anadromous fish species present in the reflecting pool during construction.

5.6.1.2 Impacts on Fish from Operation

Similar to the Estuary Alternative, the removal of the 5th Avenue Dam would allow saltwater from Budd Inlet to enter the former lake basins, transforming freshwater riverine and lacustrine aquatic habitats to estuarine habitat, except within the reflecting pool where freshwater conditions would be present, fed by groundwater. The primary impacts on fish associated with the operation of the Hybrid Alternative are related to the physical and chemical transition of the freshwater lake habitats to saltwater estuary habitat, as well as the availability and types of wetland/aquatic vegetation habitat areas in the Middle Basin. However, the Hybrid Alternative would establish a freshwater reflecting pool that does not support estuarine functions and would reduce the amount of habitat available to estuarine fish species in the North Basin.

Under the transition from a lake to an estuary (outside of the reflecting pool), the Hybrid Alternative would result in changes in salinity, water temperature, water quality, sediment deposition patterns, aquatic plants, and invasive species distribution, similar to the Estuary Alternative (Section 5.5.1.2). As described for the Estuary Alternative, DO levels would decrease and temperatures in the estuary may increase slightly from existing conditions, depending on tidal cycles, but any such changes would be within the tolerances for marine species. In the eastern portion of the existing lake basin (the freshwater reflecting pool), the isolated pool would have freshwater conditions that would maintain or improve water quality, compared to existing conditions. The Hybrid Alternative would result in less DO than currently exists in the lake basin, although it would represent better conditions than the estuary portion of the basin. This portion of the basin would likely experience fewer and less extensive algae blooms than the estuary portion due to twice daily flushing of high tide water.

Primary operational effects of the Hybrid Alternative would be related to alterations in aquatic habitat (specifically the entry of saltwater into the basin and alterations in bathymetry), due to both initial and maintenance dredging and the 5th Avenue Dam removal. In addition, potential impacts from alternative operation could include those from installation of habitat areas and overwater and in-water structures, as well as associated with the operation of long-term lighting, as described below.

Aquatic Habitat Alterations

The removal of the 5th Avenue Dam and re-establishment of estuarine habitat conditions in the majority of the site under the Hybrid Alternative would affect fish through changes in salinity and in the type and amount of aquatic habitat available. After the dam is removed, salinity in Capitol Lake at medium (average) flow conditions would be essentially the same as those presented for the

Estuary Alternative (Section 5.5.1.2), with slightly more (0.5 to 1.0 ppt) saline conditions in the Middle and North Basins.

In addition to altered salinity levels, changes in the type of habitat within the current lake basin would also occur under the Hybrid Alternative. For salmon, other anadromous species, and marine fishes, removal of the 5th Avenue Dam would provide full access to a suitable marine and estuarine habitat of approximately 215 acres (at MHHW), where none currently exists, including sub-tidal, intertidal tideflat, low marsh, and high marsh habitats. In addition, the Hybrid Alternative would result in approximately 45 acres of freshwater habitat in the reflecting pool, which would be isolated from the estuary portion of the North Basin. The reflecting pool would provide some (but not all) functions of a freshwater lake system for resident fish, but would not be utilized by anadromous fish. The estuarine habitat that is fully exposed to tidal exchange would provide productive habitat for salmon, other anadromous species, and marine fishes as the area. The North Basin's extensive shallow water habitats, with saltmarsh vegetation along the water's edge of the western portion of the basin, would provide preferred rearing habitat for juvenile salmon (Fresh 2006) and productive epibenthic and terrestrial origin prey for juvenile salmon. Along the outer wall of the reflecting pool, the edge of the accessible habitat would be a vertical wall instead of shallow, sloping habitats preferred by juvenile salmon for foraging and avoiding predators. This would reduce prey production in the area compared to a naturally sloping shoreline and increase the risk of predation for small fish such as juvenile salmon.

Over time, habitat quality in the estuary, especially the western portion of the North Basin, would improve as macroinvertebrate populations and saltwater-tolerant aquatic vegetation become established in the intertidal tideflat and marsh habitat areas. For salmon, including ESA-listed Chinook salmon, other anadromous species, and marine fishes, the estuary provided in the Hybrid Alternative would result in **moderate beneficial effects** as the full range of estuarine functions would not be develop over the entire North Basin estuary area. Conversely as with the Estuary Alternative, the saline or brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, that would result from the Hybrid Alternative is not suitable for native freshwater fish species, resulting in mortality and potential extirpation of these species in Capitol Lake, which constitutes a **significant adverse impact** on native species within this group. For non-native freshwater fish, particularly predatory fish such as bass, the extirpation of these species would be a **less-than-significant impact.**

Maintenance Dredging

As described under the Estuary Alternative (Section 5.5.1.2), removal of the dam would restore natural sediment dynamics and result in the accumulation of sediments in West Bay, requiring maintenance dredging. While there are minor differences in dredge frequency and volumes for the Hybrid Alternative, the effects of the dredging are essentially the same, with impacts on salmon and other marine or anadromous fish associated with direct entrainment and sediment and turbidity, causing **less-than-significant impacts** for anadromous and marine fish.

Habitat Areas

As described for the Estuary Alternative (Section 5.5.1.2), dredge spoils would be used to create habitat areas in the Middle Basin. The constructed habitat areas would provide high-quality migration and rearing habitat for juvenile salmonids, due to the gradual 10:1 slopes of the constructed habitat and the presence of natural vegetative communities that would become established on the nutrient-rich lake bed sediments that comprise the habitat areas.

In-water and Overwater Structures

As described for the Estuary Alternative (Section 5.5.1.2), the removal of approximately 145,000 SF of fill within the study area from the removal of the 5th Avenue Dam would increase available habitat by removing an in-water structure that can negatively affect fish through shading and by enhancing predator habitat). However, the Hybrid Alternative also includes a reflecting pool barrier pool that both represents a physical loss of habitat in the water column (from the wall footprint) and a large (36,400 SF) in-water structure. This would reduce the overall net decrease in fill of 106,400 SF. In addition, the Hybrid Alternative would include the placement of large riprap or cobble material along critical infrastructure elements such as the 4th Avenue Bridge, the I-5 Bridge, and the existing railroad bridge. The placement of this material is needed for scour protection to moderate high water velocities during large storm events in an area with the potential for increased current flow from reintroduced tidal hydrology. When considered together, the physical footprint of the dam removal, coupled with the increase in-water structure from the reflecting pool wall would have **minor beneficial effects** for salmon and other fish species expected to use the estuary based on the small increase in available habitat (at MHHW).

Artificial Lighting

Under the Hybrid Alternative, artificial lighting would be installed to light the path of the new 5th Avenue Bridge, as well as the path on the top of reflecting pool wall. As discussed under the Managed Lake Alternative in Section 5.4.1.2, any potentially negative impacts on fish would be minimized or eliminated through lighting design and placement. Based on the minimization measures, the artificial light is expected to have **less-than-significant impacts** on all of the species indicator groups.

Relocation of In-water Structures to Facilitate Maintenance Dredging

Same as the Estuary Alternative (Section 5.5.1.2), maintenance dredging would occur in West Bay under the Hybrid Alternative.

Based on the limited nature of the disturbance, the adherence to regulatory in-water work windows, and the implementation of BMPs, the relocation of piles and floats prior to maintenance dredging are expected to have minor negative effects, that are considered **less-than-significant** on the marine and anadromous fish that may be present in Budd Inlet.

Contaminated Sediment Movement and Water Quality

As with the Estuary Alternative (Section 5.5.1.2), the net movement of sediments would predominantly be from the river to the estuary and lower Budd Inlet; the water movement associated with incoming and outgoing tides of lower Budd Inlet may transport some sediment moving in the opposite direction (i.e., from lower Budd Inlet into the lowermost portion of the estuary). Only a very small amount of sediment from Budd Inlet would move upstream, and only at extremely high tides. Furthermore, any minor amount of contaminated sediment would be mixed with cleaner estuarine sediments originating from the Deschutes River. Also, the continued s load of clean sediment from the Deschutes River would, in a relatively short amount of time, bury any potentially contaminated sediment transported from the estuary. Therefore, impacts on marine or anadromous species from contaminated associated with the presence and movement of existing contaminated sediments in Budd Inlet, as well as changes to water quality parameters in the former fresh-water habitats, are expected to be **less-than-significant**.

Aquatic Invasive Species Reductions

The transition from freshwater to saltwater would impact aquatic invasive species, which influence fish through changes to habitat and changes to competition/predation conditions. Aquatic invasive plant species that are intolerant to saltwater area described under the Estuary Alternative (Section 5.5.1.2).

This would result in **moderate beneficial effects** to anadromous and marine fish by creating room for native salt-tolerant vegetation to establish, or naturally unvegetated tideflats, depending on elevations relative to the tides. Likewise, the eradication of the six non-native fish species who are competitors and/or major predators of juvenile salmon would have **moderate beneficial effects** for salmon and all other fish species expected to use the estuary.

5.6.2 Wildlife

5.6.2.1 Impacts on Wildlife from Construction

Construction impacts and the duration of impacts would be the same as those described under the Estuary Alternative. In addition to those effects, a barrier wall would be constructed to contain saltwater that would be used for the new, smaller reflecting pool.

This construction element would add additional noise from pile driving, sediment disturbance, and slightly increase the potential for turbidity and mobilization. BMPs would minimize these potential adverse impacts. The impacts on wildlife and habitat would be greater than those described for the Estuary Alternative but would still be **less-than-significant**.

5.6.2.2 Impacts on Wildlife from Operation

Long-term impacts of the Hybrid Alternative would be similar to those described for the Estuary Alternative, with the exception of the habitat implications associated with the reflecting pool. In this alternative, there would be 45 acres of deepwater freshwater habitat and fewer acres of tideflat and wetland habitat compared to the Estuary Alternative. There would also be impacts from the maintenance dredging in the West Bay.

The corresponding impacts on wildlife are described in the narrative below, comparing the effects to the Estuary Alternative and noting where there is a difference between the two alternatives.

Shellfish

The 45 acres of deepwater, freshwater habitat behind the reflecting pool barrier wall would provide some limited habitat for existing freshwater mussels. Habitat would be extremely limited in the basin compared to existing conditions. Outside of this habitat feature, the impacts of the Hybrid Alternative would be the same as those for the Estuary Alternative.

Birds

Shorebirds/Wading Birds

The 45 acres of the reflecting pool would provide minimal habitat for shorebirds and wading birds and thus would provide less habitat for this species group compared to the Estuary Alternative. These birds forage in shallow water, and the reflecting pool would not offer the extensive areas that would be available with the dynamics of the tidally influenced tideflats of the Estuary Alternative. Other than the reflecting pool, the effects of the Hybrid Alternative would be the same for shorebirds and wading birds as the Estuary Alternative. Extensive tideflat area (Table 5.4) would be available for foraging at low tide and varying levels would be available corresponding to tidal level.

Disturbance from maintenance dredging of Budd Inlet would be similar to that described under the Estuary Alternative and would be considered **less-than-significant.**

Table 5.4 Estimated Acreage Habitat Types under the Hybrid Alternative

Habitat Type	Dominant Vegetation	Estimated Acreage[1]
Submerged/Deepwater – Freshwater (Reflecting Pool)	Aquatic vegetation/open water	45
Subtidal/Deepwater Habitat – Estuarine	Aquatic vegetation/open water	238
Tideflat	--	119
Low Marsh – Estuarine	Pickleweed, fleshy jaumea	37
High Marsh – Estuarine	Tufted hairgrass, meadow barley, Douglas' aster, Baltic rush, seashore saltgrass, Pacific silverweed, sea plantain, pickleweed, fleshy jaumea, Puget Sound gumweed, lakeshore sedge	48

Habitat Type	Dominant Vegetation	Estimated Acreage[1]
Vegetated Wetland - Transitional	Sitka spruce, shore pine, Hooker's willow, oceanspray	29
Vegetated Freshwater Wetland	Willow, western red cedar, red alder, spirea, twinberry, dogwood, slough sedge, soft rush, piggyback plant	9

Notes:

1. Areas are estimated based on modeled future conditions and rounded to the nearest acre and do not account for in-water or overwater structures.

Waterfowl

Similar to the Estuary Alternative, the Hybrid Alternative would provide **moderate beneficial effects** as the system becomes more diverse and the range of foraging opportunities increases. The reflecting pool would offer some resting deepwater habitat for diving and dabbling ducks when the estuary portion of the project is at low tide.

Aerial Feeders

The impacts of the Hybrid Alternative on aerial feeders would be similar to those of the Estuary Alternative, but estuarine and freshwater ponded habitats would be fragmented and reduced in size. The reflecting pool would contain freshwater and would provide reduced production of insects that would be prey items for species that prefer insects produced from freshwater systems. Because estuarine habitat would be reduced in size, insects from this habitat would also be reduced. Overall, however, it is anticipated that the impact to aerial feeders would be **less-than-significant.**

Raptors

As with the Estuary Alternative, the type of fish supported by the estuary would shift to estuarine species. Bald eagles and osprey are adept at feeding in both freshwater and estuarine environments. Fish production in the reflecting pool would likely be lower than that of the functional estuary portion of the project. Overall, there would be **no impact** on bald eagles and osprey given that the estuary portion of the basin would provide additional habitat for juvenile salmon and may contribute to increased adult production, which are a food source for these predatory birds.

Songbirds

Impacts on songbirds from the Hybrid Alternative would be the same as those described for the Estuary Alternative.

Bats

Impacts on bats from the Hybrid Alternative would generally be the same as discussed above for the Estuary Alternative due primarily to the reduction of freshwater lentic habitat. The freshwater pool would retain approximately 45 acres of freshwater lentic habitat that may support bats; however, the majority of freshwater lentic habitat would be eliminated. Although difficult to assess because of data-gaps in our understanding of current use of Capitol Lake, as well as how the restored habitats would support the existing assemblage, it is conservatively determined that the Hybrid Alternative would have potentially **significant impacts** on Yuma myotis and little brown bats at the Woodard Bay trestle colony given the degree of change that would occur throughout the basin, but not any other bat species and to an unknown extent.

Other Water-Dependent Mammals

The reflecting pool would provide minimal habitat for water-dependent mammals such as river otters. The Hybrid Alternative would provide less ecological benefit to this species group compared to the Estuary Alternative; otherwise, the impacts on this species group are the same as those described for the Estuary Alternative.

The impacts on harbor seals and orcas from the Hybrid Alternative would be **less-than-significant**.

5.6.3 Summary of Impacts – Hybrid Alternative

Under the Hybrid Alternative, impacts on fish and wildlife would range from **beneficial** to **less-than-significant** to **significant**, with the nature and scale of impacts similar to those for the Estuary Alternative. Some habitat zones would change, and species would adapt to the altered habit conditions. For salmon, other anadromous species, and marine fishes, the estuary provided in the Hybrid Alternative would result in **moderate beneficial effects** as the full range of estuarine functions would not be develop over the entire North Basin area. Conversely, the saline or brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, that would result from the Hybrid Alternative is not suitable for freshwater fish species, resulting in mortality and potential extirpation of these species in Capitol Lake, which constitutes a **significant adverse impact** on this species group. For wildlife species, the loss of the freshwater lake, which supports emergent insects fed upon by bats, could result in a **significant impact** on the Woodard Bay trestle bat colony.

Reintroducing tidal hydrology to a portion of the current lake area would benefit many of the species of importance to the Squaxin Island Tribe, Nisqually Indian Tribe, and Confederated Tribes of the Chehalis Reservation, specifically salmon and shellfish, and potentially other fish and wildlife, as well as plants. These benefits are generally as described in Section 5.5.3 for the Estuary Alternative. Relative to the Estuary Alternative, the reflecting pool would not benefit species of importance to the tribes and would have less of an overall increase in habitat availability and access. Maintenance dredging could result in impacts on tribal resources similar to those described in Section 5.3.1.1 for the Estuary Alternative by causing physical or behavioral responses, or by affecting aquatic habitat, and potentially affecting access to fishing areas within West Bay during maintenance dredging cycles.

5.7 AVOIDANCE, MINIMIZATION, AND MITIGATION MEASURES

5.7.1 Measures Common to All Action Alternatives

Enterprise Services would avoid and minimize potential impacts by complying with regulations, permits, plans, and authorizations. These anticipated measures, and other mitigation measures that could be recommended or required, are described below.

5.7.1.1 Habitat Enhancement Plan

A Habitat Enhancement Plan would be developed and implemented for the selected alternative during the future design phase. The plan would be developed in coordination with and approved by Ecology; WDFW; City of Olympia; City of Tumwater; other applicable local, state, and federal agencies; and tribes.

Elements of the plan would vary depending on the alternative, and generally include:

- Specific habitat creation, restoration and design treatments for each habitat area (e.g., upland, riparian, wetland, and aquatic). Treatments include grading, planting, weed management, installation of habitat features, and similar treatments.
- Specific performance standards for the habitat areas to measure the success of these areas. Typical performance standards would define thresholds for wetland hydroperiod; cover, density, and diversity of native plants; and other habitat attributes.
- Adaptive management and maintenance measures to ensure that the performance standards are met. For example, if after construction, the native plant assemblages are not establishing as designed, the adaptive management actions could include additional planting, soil amendment, modification of topography, weed control, or other corrective measures. The approach to meeting performance goals and the frequency of active management required to meet the performance goals for the habitat enhancements would vary across the action alternatives. This would be further defined in the permitting process
- Measures to address nuisance and invasive species within the project area. Potential approaches to managing aquatic invasive species would include hand-maintenance (i.e., pulling or seed head removal) and the use of bottom barriers and screens to limit growth. Noxious and invasive wildlife species, including nutria and Canada geese, will continue to be managed by the U.S. Department of Agriculture, under agreement with Enterprise Services.

5.7.1.2 Construction

During construction of any action alternative, standard overwater and in-water construction and demolition BMPs would be implemented in accordance with environmental regulatory permit requirements. Specific in-water construction periods would also be confirmed through the project permitting process to minimize potential impacts of pile driving and other in-water construction activities on salmonid species. The anticipated in-water work windows of June 1 to August 15 and November 15 to February 15 each year would generally serve to protect both outmigrating juvenile salmon and returning adults. In addition, under all action alternatives, dredged sediments would be re-used to create habitat areas. This would substantially minimize the need for off-site disposal of dredge spoils that can have negative impacts if this includes in-water disposal.

Other BMPs common to all action alternative would include the following:

- Where feasible, the project will utilize vibratory pile installation methods for all pile installation, including both sheet-pile and round piles. Impact driving methods will only be used if geotechnical conditions require such methods for achieving required loading requirements, and where feasible, will be limited to pile proofing only.
- Appropriate BMPs and sound attenuation methods (e.g., bubble curtains) would be developed in coordination with the regulatory agencies and environmental permitting processes, and they would be implemented to minimize potential impacts of any impact pile driving activities.
- During construction, contractors would use BMPs (for example, sediment curtains) to avoid unintentional impacts on habitat and water quality during dredging, habitat island creation, and in-water construction.
- Suspended tarps, or similar containment measures, would be used to contain falling debris during construction of the new over-water structures.
- Cleared upland areas will be restored to preconstruction grades and replanting the areas with appropriate native herbaceous and woody species.
- Temporary erosion and sediment control measures and a stormwater management and pollution prevention plan will be implemented.
- Spillage of concrete or other construction material into the water will be prevented.
- A Spill Prevention and Control Plan will be implemented.

5.7.1.3 Operation

The project has been designed to minimize the permanent and temporary impacts of the alternatives. BMPs common to all action alternatives would include the following:

- During recurring dredging, contractors would use BMPs (for example, sediment curtains) to avoid unintentional impacts on habitat and water quality during dredging.
- To the extent practicable, minimize the width of boardwalks and utilize fish friendly designs, utilizing grated decking and a minimum number of support piles.

Following this SEPA review process, and as part of the design and permitting of the selected alternative, the Corps, as federal lead agency, will conduct its own review of the project. In addition, the Corps will be consulting under Section 7 of the federal Endangered Species Act with the U.S. Fish and

Wildlife Service and National Marine Fisheries Service. Washington Department of Fish and Wildlife would also review the project under state Hydraulic Project Approval requirements. Additional measures may be identified under one or both of these processes that could further reduce potential impacts on tribal resources. Pursuant to NEPA, the Corps would conduct its own analysis related to potential impacts of the project on tribal resources.

5.7.2 Measures Specific to Each Action Alternative

5.7.2.1 Managed Lake Alternative

- Installation of the buttressing berm would be timed to occur at low tide if feasible.
- Lights on the new non-vehicular bridge would be positioned to illuminate only the walkways or use other methods, such as hoods that prevent excess light from reaching the water surface.

5.7.2.2 Estuary and Hybrid Alternatives

- Cofferdams or other appropriate measures would be used to isolate work areas from deepwater areas for the removal of the existing 5th Avenue Dam.
- Lights on the new 5th Avenue Bridge would be positioned to illuminate only the walkways or use other methods, such as hoods that prevent excess light from reaching the water surface.
- Trees removed to realign Deschutes Parkway would be replaced based on City of Olympia's tree protection ordinances and critical areas regulations.
- Coordination with wildlife experts would occur during the design phase to identify opportunities to support bats. Based on consultation with WDFW and a local bat expert after the Draft EIS was issued, the following potential mitigation opportunities have been identified:
    - A population study of bat use of Capitol Lake and the lower Deschutes River could be conducted prior to the initiation of construction to establish a baseline that would allow local populations to be tracked across time, post-construction.
    - An examination of freshwater lentic enhancement sites within a 5- to 10-mile radius around Capitol Lake could be conducted to assess opportunities for directly offsetting for loss of lentic habitat.
    - Habitat enhancement components could be built into the project design that would support bats, to the extent possible, including placement/retention of standing snags and/or installation of bat roost sites (i.e., bat boxes).
    - During construction and maintenance activities, existing features – both natural and artificial – located within the project area that may provide roosting opportunities for bats will be surveyed for bat occupancy prior to their disturbance. If found to be

occupied, appropriate steps will take place to ensure minimum disturbance to individuals.

- The Woodard Bay trestle could be assessed to evaluate if opportunities exist to further its creosote cleanup while enhancing roosting conditions for bats.

5.7.3 Significant Unavoidable Adverse Impacts

As described in the analysis above, most potential impacts on fish or wildlife from any of the alternatives would not rise to the level of significance as defined by the established significance criteria. The analysis did, however, identify some potential significant unavoidable adverse impacts, as summarized below by alternative.

5.7.3.1 No Action Alternative

- **No significant impacts on fish or wildlife.**

5.7.3.2 Managed Lake Alternative

- **No significant impacts on fish or wildlife, either during construction or operation.**

5.7.3.3 Estuary Alternative

- **Operational Impacts on Fish from Aquatic Habitat Alterations**: The brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, that would result from the Estuary Alternative is not suitable for freshwater fish species, resulting in mortality to these species; this would be a **significant unavoidable impact** on native species in this group.
- **Operational Impacts on Wildlife from Habitat Alterations:** Although difficult to assess because of data-gaps in the understanding of current use of Capitol Lake, as well as how the restored habitats would support the existing assemblage, it is conservatively determined that there would be a **significant unavoidable impact** on Yuma myotis and little brown bats at the Woodard Bay trestle colony. This is because of the size of the colony and the change to an estuarine environment under the Estuary Alternative.

5.7.3.4 Hybrid Alternative

- **Operational Impacts on Fish from Aquatic Habitat Alterations**: The saline or brackish water in the North and Middle Basins, and to a lesser degree in the South Basin, that would result from the Hybrid Alternative is not suitable for freshwater fish species, resulting in mortality and potential extirpation of these species in Capitol Lake; this would be a **significant unavoidable adverse impact** on native species in this group.

- **Operational Impacts on Wildlife from Habitat Alterations**: As with the Estuary Alternative, it is conservatively determined that there would be a **significant unavoidable impact** on Yuma myotis and little brown bats at the Woodard Bay trestle colony.

5.7.4 Beneficial Effects

As described in the analysis above, project actions under some alternatives would result in beneficial effects. These effects can be characterized as minor, moderate, or substantial, based on the benefits they provide to fish and wildlife resources. For each project alternative, beneficial effects identified in the analysis are summarized below.

5.7.4.1 Managed Lake Alternative

- **Operational Benefits to Wildlife from Habitat Alterations:** For a number of songbirds such as yellow warbler, chickadees, and wrens, the transition of 60 acres of deepwater habitat to riparian and upland habitat areas would have a **minor beneficial effect** because of increased foraging and nesting opportunities.
- **Operational Benefits to Wildlife from Habitat Alterations:** The increase in songbirds resulting from the transition of deepwater habitat would, in turn, have a **minor beneficial effect** for some raptors, such as Cooper's and sharp-shinned hawks, because of the additional hunting opportunities on songbirds that use the constructed habitat areas.
- **Operational Benefits to Fish from Habitat Alterations:** Alterations in lake bathymetry and water depths in the lake associated with dredging events would have a **minor beneficial effect** on fish, for both the anadromous and freshwater species groups.

5.7.4.2 Estuary Alternative

- **Operational Benefits to Fish from Habitat Alterations:** Conversion of freshwater lake habitat to a tidally influenced brackish estuary would result in **substantial beneficial effects** to fish, specifically anadromous species and marine species, potentially including ESA-listed Chinook salmon and steelhead. This is due to the restoration of natural estuarine salinity gradients, the extirpation of freshwater predator species, and the development of mudlflats and/or marine vegetation.
- **Operational Benefits to Fish from Reduced Overwater and In-water Structures:** The large net reduction in overwater and in-water structures under the alternative that would result from dam removal would result in **moderate beneficial effects** for salmon and marine fish species expected to use the estuary, potentially including ESA-listed Chinook salmon and steelhead. This is due to the increase in available in-water habitat for these species.
- **Operational Benefits to Wildlife from Habitat Alterations:** Shellfish, particularly the more mobile species such as crabs, would likely experience a **moderate beneficial effect**, because of the large expansion of suitable habitat within the estuary.

- **Operational Benefits to Wildlife from Habitat Alterations:** Shorebirds and wading birds, such as heron, would experience a **substantial beneficial effect** from the conversion of freshwater to estuarine habitat, because of an increase in suitable habitat and changes in the types of prey available for this species group.
- **Operational Benefits to Wildlife from Habitat Alterations:** Waterfowl would likely experience a **moderate beneficial effect**, because of an increase in foraging opportunities.
- **Operational Benefits to Wildlife from Habitat Alterations:** For a number of raptors and songbirds, the transition of 60 acres of deepwater habitat to riparian and upland habitat would have a **minor beneficial effect** because of increased foraging and nesting opportunities.
- **Operational Benefits to Wildlife from Habitat Alterations:** The benefits to salmon from the Estuary Alternative would also result in a **minor beneficial effect** for orcas (an ESA-listed species), as orcas utilize salmon as a key prey base.

5.7.4.3 Hybrid Alternative

- **Operational Benefits to Fish from Reduced Overwater and In-water Structures:** The conversion of freshwater lake habitat to a tidally influenced brackish estuary, which is mostly, but not entirely open to the full range of tidal cycles, would result in **moderate beneficial effects** to fish, specifically anadromous species and marine species, potentially including ESA-listed Chinook salmon and steelhead. This is due to the restoration of natural estuarine salinity gradients, the extirpation of freshwater predator species, and the development of mudlflats and/or marine vegetation.
- **Operational Benefits to Fish from Reduced Overwater and In-water Structures:** The net reduction in overwater and in-water structures under the Hybrid Alternative from dam removal would result in **minor beneficial effects** for salmon and marine fish species expected to use the estuary, potentially including ESA-listed Chinook salmon and steelhead. This is due to the increase in available in-water habitat for these species.
- **Operational Benefits to Wildlife from Habitat Alterations**: Shellfish, particularly the more mobile species such as crabs, would likely experience a moderate beneficial effect, because of the large expansion of suitable habitat within the estuary.
- **Operational Benefits to Wildlife from Habitat Alterations**: Shorebirds and wading birds, such as heron, would experience a moderate beneficial effect from the conversion of freshwater to estuarine habitat, because of an increase in suitable habitat and changes in the types of prey available for this species group.
- **Operational Benefits to Wildlife from Habitat Alterations:** Waterfowl such as diving and dabbling ducks would likely experience a **moderate beneficial effect**, because of an increase in foraging opportunities.
- **Operational Benefits to Wildlife from Habitat Alterations:** For a number of raptors and songbirds, the transition of 60 acres of deepwater habitat to riparian and upland habitat

areas would have a minor beneficial effect because of increased foraging and nesting opportunities.

- **Operational Benefits to Wildlife from Habitat Alterations:** The benefits to salmon from the Hybrid Alternative would also result in a minor beneficial effect for ESA-listed orcas, as orcas utilize salmon as a key prey base.

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Appendix A Annotated Bibliography Addressing Salmon Ecology Topics Related to CLDE Long-Term Management Draft EIS Comments

Annotated Bibliography Addressing Salmon Ecology Topics Related to Capitol Lake – Deschutes Estuary Long-Term Management Draft EIS Comments

Prepared by: Pete Lawson and Cameron Reyes, Environmental Science Associates

July 2022

Introduction

The Capitol Lake Improvement and Protection Association (CLIPA) has provided comments on the Capitol Lake – Deschutes Estuary (CLDE) Long-Term Management Project Draft Environmental Impact Statement (EIS) and previously during the EIS Scoping comment period. CLIPA has made several assertions related to the evaluation of impacts and benefits to salmon relative to the project alternatives, and has requested that the EIS project team review studies and reports attached to, and/or referenced by CLIPA in their comment letters. After a review of these comments, CLIPA's comment letters can be summarized into four main assertions:

1. Juvenile salmon reared in a freshwater environment such as Capitol Lake perform as well as those reared in an estuarine environment. CLIPA also suggests that growth of Chinook salmon in Capitol Lake is more rapid than growth rates observed in estuaries.
2. The Draft EIS relies too much on theoretical rather than actual study findings, specifically that the Draft EIS confidently states that there would be substantial benefits for Chinook salmon without any substantiation.
3. There would be increased risk of predation on juvenile salmonids if the dam is removed due to multiple compression points that would occur in the basin (the railroad trestle and I-5 Bridge); an increase from the predation that occurs at the 5th Avenue fish ladder.
4. The Draft EIS places too much emphasis on the steep salinity gradient within Capitol Lake. The comments suggest that if the dam is removed, salmon will experience essentially the same salinity gradient at the base of Tumwater Falls. Also, since there is some overtopping of the dam during high tides, there is already salinity in portions of the North Basin.

This annotated bibliography provides a review of literature that is relevant to the above assertions. The bibliography is organized into two sections: (1) literature referenced in the CLIPA comment letters submitted during the Draft EIS and Scoping comment periods, including an attached report from CLIPA Co-Chair Jack Havens (2019); and (2) relevant additional literature identified by the EIS Project Team on the above topics.

Literature Referenced in CLIPA comments and Havens (2019)

CLIPA comments and Havens (2019) draws the most support for the above assertion on Chinook lake rearing compared to estuarine rearing from the two sources below; Engstrom-Heg (1955) and Koehler et al. (2006).

Engstrom-Heg, R.T. 1955. *Environmental Relationships of Young Chinook Salmon in Capitol Lake and the Deschutes River System.* State of Washington Department of Fisheries, Olympia, Washington.

This paper provides data on the first release of Chinook salmon juveniles into Capitol Lake in 1955 following completion of an earth fill dam across the lower end of the Deschutes River estuary in 1950. Capitol Lake proved to be a rich but highly seasonal feeding ground, with the Chinook salmon growing faster and larger than the same stock reared in hatcheries. Additionally, this paper reports that predation of juvenile Chinook salmon in the lake was rare to negligible.

This paper is one basis for claims that Chinook salmon grow rapidly in Capitol Lake; however, this paper only considers data collected from a single year (1955) of hatchery Chinook salmon releases into the lake and does not assess growth of hatchery releases into the estuary, prior to dam installation. In addition, the Chinook growth rates in Capitol Lake were not compared against a reference estuary, but rather hatchery fish, whose growth is dependent on the composition, volume, and timing of fish feed application, as well as the water quality in the hatchery rearing ponds.

In the 67 years since the study was conducted, there have been changes to physical, biological, and chemical conditions and processes in the lake that affect the quantity and quality of aquatic habitat. Regarding lake flora and fauna at the time of the study, Engstrom-Heg (1955) acknowledged "*The present species are no doubt pioneer forms characteristic of new fresh-water lakes, and until the climax flora and fauna become established, further shifts in the biotic composition may be expected.*" Other changes include alterations in lake bathymetry and water quality, non-native fish introductions and changes in species assemblages, long-term Chinook population trends, food web dynamics, and annual temperature, total dissolved oxygen, and nutrient trends, which may have changed in ways that negatively affect juvenile Chinook salmon growth and predation rates. For example, Engstrom-Heg (1955) reported that largemouth bass were "*probably absent*" in the main lake while no smallmouth bass were reported, while Hayes et al. (2008) indicate that both species are present in the lake. Current level of predation on hatchery Chinook juveniles in Capitol Lake is unknown; however, some predation likely does exist within the lake or at the dam outlet, where marine mammal, avian, and piscivorous fish predators may congregate at the existing bottleneck created at the dam outlet.

While the historical data can be useful, more current studies on native and hatchery Chinook salmon growth and development in lacustrine versus estuarine conditions should be considered.

Koehler, M.E., K.L. Fresh, D.A. Beauchamp, J.R. Cordell, C.A. Simenstad, and D.E. Seiler. 2006. *Diet and Bioenergetics of Lake-Rearing Juvenile Chinook Salmon in Lake Washington.* Transactions of the American Fisheries Society 135: 1580-1591.

This paper studied aspects of the trophic ecology of naturally and hatchery-produced juvenile Chinook salmon rearing in the littoral zone of highly urbanized Lake Washington in King County.

Bioenergetics modeling estimated that naturally produced juvenile Chinook salmon had high consumption rates and were generally feeding close to their maximum ration, even after large numbers of hatchery-produced Chinook salmon entered the lake. The feeding rates, growth rates, and proportions of maximum daily ration from the modeling suggested that under current conditions, both naturally produced and hatchery-produced juvenile Chinook salmon were finding ample food in littoral habitats of Lake Washington.

The bioenergetics models created by Koehler et al. (2006) estimated that the lineal growth rates of wild juvenile Chinook salmon in the lake were similar to estuarine and nearshore marine growth in Puget Sound, suggesting that estuary restoration may not have a significant effect on juvenile Chinook salmon in the system. However, as Lake Washington and Capitol Lake differ greatly in size (Table 1) and configuration (with self-sustaining numbers of naturally occurring Chinook in the two major tributaries to Lake Washington, Cedar and Sammamish Rivers). Any comparisons of Chinook bioenergetics between the two locations should take this into consideration. Physical, chemical, and biological conditions are likely less stable in Capitol Lake than in Lake Washington, due to its substantially smaller size and depth. For example, invertebrate populations in Capitol Lake are likely not as stable as Lake Washington, as environmental parameters such as water temperature, water quality, and sediment deposition may be more variable in the smaller Capitol Lake system, potentially impacting the abundance and diversity of invertebrate populations. For example, Koehler et al. (2006) assumed Lake Washington water temperatures (a key growth variable) during the juvenile Chinook outmigration period that were 3° to 5°F warmer than were reported in the Engstrom-Heg (1955) study.

Table 1. Lake statistics.

Parameter	Lake Washington	Capitol Lake
Trophic Status	Mesotrophic	Eutrophic
Basin Size (square miles)	492	16
Shoreline Length (miles)	76.0	5.3
Lake Area (acres)	21,500	270
Mean Depth (feet)	108	9
Maximum Depth (feet)	214	20
Volume (acre-feet)	2,350,000	2,400

Data sources: Lake Washington (https://green2.kingcounty.gov/lakes/LakeWashington.aspx); Capitol Lake (https://www.co.thurston.wa.us/health/ehrp/pdf/AR10-11/AR09-10--AR10-11_Budd.pdf); Toft 2001.

In several instances, Havens (2019) uses direct quotes from Koehler et al. (2006) and secondarily references additional sources to support these quotes. These additional sources, however, do not necessarily support the direct claims made by Havens (2019). The EIS Project Team has reviewed the sources provided by Havens. The sources listed below are those that do not necessarily support Havens' (2019) uses of the direct quotes from Koehler et al. (2006).

Burger, C.V., R.L. Wilmot, and D.B. Wangaard. 1985. *Comparison of Spawning Areas and Times for Two Runs of Chinook Salmon (*Oncorhynchus tshawytscha*) in the Kenai River, Alaska.* Canadian Journal of Fisheries and Aquatic Sciences 42: 693-700.

This paper discusses a radio transmitter tagging study of adult Chinook salmon in the lake-fed Kenai River that revealed two distinct runs of salmon. The earlier migrating run entered the system from May through June and spawned in tributaries to the Kenai River; the later migrating run entered from late June through August and spawned in the main stem.

Havens (2019) references Burger et al. (1985) via the use of quotes from Koehler et al. (2006), which state, "*Lake residence is a rare life history strategy for ocean-type Chinook salmon (e.g., Burger et al. 1985)*," and "*Rearing in lakes is rare for ocean-type Chinook salmon populations under natural conditions (e.g., Burger et al. 1985).*" Presumably Havens (2019) is suggesting the rarity of the life history makes it more important to maintain in Capitol Lake. However, the opposite interpretation could also be made: the rarity highlights the unnatural nature of the current lake configuration. Burger et al. (1985) focuses on run-timing and adult migration and spawning in a lake-fed river system; it does not discuss rearing or juvenile use of lakes. Additionally, Capitol Lake is a man-made terminal lake in the Deschutes River system that is geomorphologically and ecologically different from the lake-fed Kenai River.

Duffy, E.J. 2003. *Early Marine Distribution and Trophic Interactions of Juvenile Salmon in Puget Sound (Master of Science thesis).*

This paper found that foraging conditions for juvenile salmon were dynamic and varied spatially, annually, and seasonally. Ultimately, this paper suggests that spatial and temporal differences in environmental conditions and the forage base may significantly influence the potential for growth and survival of juvenile salmon entering different areas of Puget Sound.

Duffy (2003) provides simulated growth rates of juvenile Chinook salmon in estuary and nearshore marine environments of the north and south Puget Sound. These data act as a point of comparison for Koehler et al. (2006). Data from Duffy (2003) demonstrated that growth rates in estuaries and nearshore marine habitats of Puget Sound were more variable, but at times exceeded the growth rates in Lake Washington.

Healey, M.C. 1982. *Juvenile Pacific Salmon in Estuaries: The Life Support System.* Pages 315-341 in V.S. Kennedy, editor. Estuarine comparisons. Academic Press, New York.

This report summarizes information on the abundance, food requirements, and production of five species of Pacific salmon (genus *Oncorhynchus*) in two estuaries in southern British Columbia, and compares some of these features among seven other estuaries. The findings indicate that juvenile salmon eat a variety of taxa, but the majority of prey tended to be detritus feeders, indicating that the food web supporting juvenile salmon is detritus based. This paper concluded that the value of an estuary as rearing habitat for juvenile salmon appears to be influenced by delta configuration and by the efficiency with which allochthonous organic carbon is trapped.

Healey (1982) provides growth rates of juvenile Chinook salmon in estuary environments of British Columbia. These data act as a point of comparison with Koehler et al. (2006). Data from Healey (1982) demonstrated that growth rates in the Nanaimo River estuary exceeded the growth rates in Lake Washington.

Miller, J.A., and C.A. Simenstad. 1997. *A Comparative Assessment of a Natural and Created Estuarine Slough as Rearing Habitat for Juvenile Chinook and Coho Salmon.* Estuaries 20:792–806.

This paper assessed the functional equivalency of the created slough in providing suitable rearing habitat for two species of juvenile salmon, Chinook and coho, by comparing short-term otolith growth rates, residence times, and forage in a created and natural estuarine slough on the Chehalis River in Washington. No significant differences in the number or width of coho daily otolith increments were detected between the sloughs. Juvenile salmon residence and emigration times were comparable between the two estuaries; however, the salmon in the created slough had emptier stomachs, possibly because of reduced prey availability and/or foraging efficiency.

Data from this paper indicate that a created estuarine slough provided rearing habitat for migrating juvenile Chinook salmon comparable to the adjacent natural slough. The authors noted lower foraging efficiencies in the created slough, despite growth rates comparable with those in the natural slough. The paper suggests that greater physical variability in the created slough and the presence of predators are possible explanations for lowered juvenile salmon foraging efficiencies, but additional research needs to be conducted.

Rondorf, D.W., G.A. Gray, and R.B. Fairley. 1990. *Feeding Ecology of Subyearling Chinook Salmon in Riverine and Reservoir Habitats of the Columbia River.* Transactions of the American Fisheries Society 119:16–24.

This paper found that, in the Columbia River, a preference analysis indicated that subyearling Chinook salmon did not eat food items in proportion to food availability; they preferred small zooplankton least and terrestrial insects most. Diets shifted to *Daphnia* spp. and terrestrial insects in a reservoir habitat primarily due to the high availability of those food items and the low availability of others. The switch to food items abundant in reservoirs enabled subyearling Chinook salmon to use the reservoirs as nursery areas. However, the use of *Daphnia* spp. may entail a higher foraging cost per energy unit gained because of the small size of the prey.

This paper demonstrates that juvenile Chinook salmon maintain a prey preference, but ultimately feed on whatever prey items are most abundant in their rearing areas, whether that is riverine or reservoir habitat.

Additional Relevant Literature

The below literature includes both those studies cited in the Draft EIS and additional studies identified by the EIS Project Team as potentially relevant to the analysis of impacts.

Benefits of Estuary Habitat to Anadromous Salmonids

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. *The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function.* Pages 343–364 in V.S. Kennedy, editor. Estuarine comparisons. Academic Press, New York.

This paper reviewed literature on the role of estuaries in the life history of Pacific salmon. Based on their literature review, the authors hypothesized that Pacific salmon use Washington's estuaries for:

(1) productive foraging, (2) physiological transition, and (3) refugia from predators. However, these functions have probably changed due to salmon culture practices and alterations of estuarine habitat, and it is possible these changes could adversely impact salmon growth and survival.

The literature reviewed in this paper suggests that estuaries play an important role in the life history of Chinook salmon, but while important and relevant, the literature reviewed in this paper is over 40 years old and newer literature should be considered.

Thorpe, J.E. 1994. *Salmonid Fishes and the Estuarine Environment.* Estuaries 17(1A):76-93.

This paper is a review of literature that supports the notion that estuaries offer salmonids three primary advantages: productive foraging, relative refuge from predators, and a physically intermediate environment for transition from freshwater to marine physiological control systems. Evidence from this literature review suggests that for Chinook salmon the estuary is important for all three reasons – as a profitable foraging area, an intermediate environment for physiological adjustment, and as a predator refuge from mergansers.

Magnusson, A., and R. Hilborn. 2003. *Estuarine Influence on Survival Rates of Coho (*Oncorhynchus kisutch*) and Chinook Salmon (*Oncorhynchus tshawytscha*) Released from Hatcheries on the U.S. Pacific Coast.* Estuaries 26(4B):1094-1103.

This paper examined data from coded-wire tagging of hatchery fish to estimate the survival from release until maturity, and related this survival to several indicators of estuarine condition. They found a significant relationship between the survival of Chinook salmon and the percentage of the estuary that is in pristine condition. This study demonstrates for the first time a direct link between estuarine condition and survival of salmon through their entire life history, suggesting that subyearling Chinook salmon are dependent on estuarine habitat for growth and transition from fresh to saltwater.

This paper directly supports the preservation of existing high-quality estuary habitat as a key component of salmon recovery plans by showing that pristine estuaries have much higher Chinook salmon survival rates than degraded estuaries. It also suggests that larger scale estuary restoration focused on providing the maximum amount of estuarine ecological function, such as the proposed CLDE Estuary Alternative, would also help maximize Chinook salmon survival and restoration of estuarine habitat.

Price, C.S., and C.B. Schreck. 2003. *Stress and Saltwater-Entry Behavior of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*): Conflicts in Physiological Motivation.* Canadian Journal of Fisheries and Aquatic Sciences 60:910-918.

This paper describes two experiments that were conducted to determine the effects of a mild or severe stressor on the saltwater preference of juvenile spring Chinook salmon yearlings. The experiments found that both a mild chasing stressor and a more severe confinement stressor decreased the willingness of juvenile spring Chinook salmon to remain in saltwater at a developmental stage when unstressed fish prefer salt to freshwater.

The findings of this study support the restoration of an estuary that would enable juvenile salmon to more easily move between salt and freshwater, especially when those fish are presented with environmental stressors.

Campbell, L.A., A.M. Claiborne, and J.H. Anderson. 2017. *Salish Sea Survival Project (4): 2017 Annual Report.* Washington Department of Fish and Wildlife Fish Program, Science Division.

In this study, the authors used otolith chemistry to reconstruct the juvenile life history of Chinook salmon returning to five Puget Sound populations. This work shows compelling evidence that the smallest migrants (35–60mm) survive and contribute to adult returns (estimated to be as much as 35% of returning adults in this study).

The authors found that river basins with about 50% of the natural estuary intact were much more likely to exhibit a fry life history among progeny of their returning adults. This work supports the idea that restoring Capitol Lake to an estuary could provide more habitat for the Chinook salmon fry life history and thereby increase the Chinook salmon production of the Deschutes River.

Sharpe C., C. Carr-Harris, M. Arbeider, S.M. Wilson, and J.W. Moore. 2019. *Estuary habitat associations for juvenile Pacific salmon and pelagic fish: Implications for coastal planning processes*. Aquatic Conservation: Marine and Freshwater Ecosystems 29 (10), 1636-1656

This paper focuses on fish sampling in the Skeena River estuary (British Columbia, Canada) that was used for a basis of comparison between simple habitat-type models and models with more complex biophysical variables to predict the variability in relative abundance of juvenile Chinook, coho, and sockeye salmon, along with pelagic fish species (Pacific herring and surf smelt). The paper summarizes the current knowledge of how estuaries (such as the proposed CLDE Estuary Alternative) act as nurseries for fish that support fisheries through both providing refuge from predators and by providing elevated prey resources relative to adjacent marine or freshwater environments.

Chalifour, L., D.C. Scott, M. MacDuffee, S. Stark, J.F. Dower, T.D. Beacham, T.G. Martin, and J.K. Baum. 2020. *Chinook Salmon Exhibit Long-term Rearing and Early Marine Growth in the Fraser River, British Columbia, a Large Urban Estuary.* Canadian Journal of Fisheries and Aquatic Sciences 78(5):539-550.

This paper uses genetic stock identification and otolith analyses to quantify estuarine habitat use by Chinook salmon in the Fraser River. This study found that small fry (<54mm) were exclusively caught in the low-salinity marsh, suggesting that fish below this size may not be optimized to transition to higher salinities.

Evidence from this paper supports the idea that restoring Capitol Lake to an estuary could provide juvenile Chinook salmon with a transition zone where they could rear and mature to an appropriate size or age in which they can physiologically tolerate marine waters.

<u>*Non-natal Chinook Estuary Use*</u>

Beamer, E.M., W.T. Zackey, D. Marks, D. Teel, D. Kuligowski, and R. Henderson. 2013. *Juvenile Chinook Salmon Rearing in Small Non-Natal Streams Draining into the Whidbey Basin.* Skagit River System Cooperative, LaConner, WA.

This paper analyzed 6 years of electrofishing data from 63 small coastal streams of the Whidbey Basin. Their statistical analysis suggested that four factors influence whether juvenile Chinook salmon were present within Whidbey Basin small streams: (1) distance to nearest Chinook salmon-bearing river, (2) stream channel slope, (3) watershed area, and (4) presence and condition of culverts at the mouth of a stream. The smaller streams in this study are often not considered salmon habitat because many flow seasonally and do not provide habitat for spawning salmon. However, the results of this study show that numerous small streams entering the Whidbey Basin do provide rearing habitat for fry migrant Chinook salmon originating from the three nearby rivers (Skagit, Snohomish, and Stillaguamish).

Information from this study suggests the importance of non-natal habitats to juvenile Chinook salmon. Restoring Capitol Lake to an estuary may provide additional rearing habitat to juvenile Chinook salmon from nearby basins in addition to the Deschutes Basin populations. The Nisqually River estuary is the next estuary to the east from Capitol Lake and is located in the South Puget Sound.

Hayes, M.C., S. Hodgson, C.S. Ellings, W.D. Duval, and S.P. Rubin. 2019. *Seasonal Use of a Non-natal Marine Basin by Juvenile Hatchery Chinook Salmon.* Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 11:437-453.

This paper examined the frequency of hatchery-reared juvenile Chinook salmon that migrated from different marine basins to the Nisqually River estuary, which lies within the southernmost marine basin in Puget Sound. The data revealed a consistent pattern showing that most of the tagged fish (72%) were from the nearby Nisqually River, but fish from more northerly marine basins (hereafter, "Outbasin") were also common. In April and May, 99% of captured fish were originally released into rivers adjacent to the South Basin, but in August and September 90% of the fish that were captured had originated from rivers adjacent to Outbasin locations (including fish from nine Puget Sound rivers, and 14 hatcheries, as far as 130 km from the Nisqually River).

Information from this study suggests the importance of non-natal habitats to artificially propagated salmon. Restoring Capitol Lake to an estuary may provide additional rearing habitat to juvenile Chinook salmon from nearby basins in addition to the Deschutes Basin populations. The Nisqually River estuary is the next estuary to the east from Capitol Lake and is located in the South Puget Sound.

Predation in Estuaries; Salinity Gradient

Hayes, M.P., T. Quinn, and T.L. Hicks. 2008. *Implications of Capitol Lake Management for Fish and Wildlife.* Report prepared for Capitol Lake Adaptive Management Program Steering Committee by the Washington Department of Fish and Wildlife.

This report evaluated some of the biological consequences of maintaining Capitol Lake as a freshwater lake or restoring it to an estuary. Based on an extensive search of peer-reviewed and gray literature, and interviews with various species, habitat, general ecology, and restoration experts, the authors concluded that removal of the 5th Avenue Dam would restore a fair semblance of the estuarine tidal flux followed by a positive response by anadromous fishes. The authors attributed the predicted positive response to a combination of factors including: (1) the elimination of the bottleneck (expected to reduce predator levels on anadromous fishes by fish-eating birds, fishes, and mammals, and facilitate passage of anadromous fishes during their entry for spawning, and exit of juveniles; (2) restoration of the mobility of the salt wedge over something approaching its potential reach (expected to improve rearing conditions for juveniles and also facilitate passage during the life stage-specific entries and exits of the difference anadromous species); and (3) restoring a saline prism to a significant area of the previous Capitol Lake footprint (expected to contribute to improving foraging conditions through elimination of the freshwater vegetation biomass, and reduction of predation by birds, fishes, and mammals associated with freshwater conditions). The authors also expected that water quality for the life stages of anadromous species will be improved and that anadromous species will be exposed to fewer conditions where contaminants and toxins may be concentrated, although some degree of uncertainty exists about the latter effect.

This paper noted that there was a general lack of specific studies of Capitol Lake and estuaries similar to Budd Inlet, as well as a poor understanding of species-habitat associations that can readily be translated into population-level responses to the type of habitat changes considered in the paper.

Predation on Juvenile Chinook Salmon in Estuary

Havens (2019) states the presence of four "predator favorable" habitats, which he also refers to as "marine water compression points," in the Capitol Lake basin. He indicates that these four areas may result in increased predation under the Estuary Alternative. However, under existing conditions, there exists a major "marine water compression point" at the outlet of the 5th Avenue Dam, where anadromous fish must enter and exit the lake through a small fish ladder, thus exposing such fish to predation.

In addition, while the railroad trestle and I-5 crossing may represent locations where piscivorous fish and marine mammals may preferentially feed if the estuary is restored, these areas likely serve as predator habitat under existing conditions (e.g., bass predation), and under the estuary restoration there will be a reduction of predation on anadromous salmonids by birds, fishes, and mammals associated with freshwater conditions.

It should be noted the science indicates that estuaries provide refuge to young fishes by providing turbid waters and nearshore habitat complexity (Bottom et al. 2005; Gregory 1994; Gregory and Levings 1998; Simenstad et al. 1982; St. John et al. 1992) that serves to decrease predation risk to small and young fishes (Alofs and Polivka 2004; Heck and Orth. 2000).

- Alofs, K.M., and K.M. Polivka. 2004. *Microhabitat-scale influences of resources and refuge on habitat selection by an estuarine opportunist fish*. Marine Ecology Progress Series, 271, 297–306.
- Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, and M.H. Schiewe. 2005. *Salmon at river's end: The role of the estuary in the decline and recovery of Columbia River salmon* (NOAA Technical Memorandum NMFS-NWFSC-68). Washington, DC: US Department of Commerce.
- Gregory, R.S. 1994. *The influence of ontogeny, perceived risk of predation, and visual ability on the foraging behavior of juvenile Chinook salmon*. Pages 271-284 in D.J. Stouder, K.L. Fresh, and

R.J. Feller (eds.). Theory and Application in Fish Feeding Ecology. Belle Baruch Library in Marine Science Number 18. University of South Carolina Press, Columbia.

- Gregory, R.S., and C. Levings. 1998. *Turbidity reduces predation on migrating juvenile Pacific salmon*. Transactions of the American Fisheries Society 127:275-285.
- Heck, K.L., G. Hays, and R.J. Orth. 2000. *Critical evaluation of the nursery role hypothesis for seagrass meadows*. Marine Ecology Progress Series, 253, 123–136.
- Sheaves, M., R. Baker, I. Nagelkerken, and R.M. Connolly. 2015. *True value of estuarine and coastal nurseries for fish: Incorporating complexity and dynamics.* Estuaries and Coasts, 38, 401–414.
- Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. *The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function*. In: Kennedy, V.S. (Ed.), Estuarine Comparisons. Academic Press, New York, NY, pp. 343–364.
- St. John, M.A., J.S. Macdonald, P.J. Harrison, R.J. Beamish, and E. Choromanski. 1992. *The Fraser River plume: Some preliminary observations on the distribution of juvenile salmon, herring, and their prey*. Fisheries Oceanography, 1, 153–162.

Appendix B Annotated Bibliography Addressing Bat Ecology Related to CLDE Long-Term Management Draft EIS Comments

Annotated Bibliography; Bat Ecology
Capitol Lake-Deschutes Estuary Long-term Management EIS

Prepared by: Jeff Barna, MS, Senior Wildlife Ecologist, Environmental Science Associates

July 2022

Introduction

Several comments received on the Capitol Lake-Deschutes Estuary Draft EIS requested clarification on potential impacts on local bat populations and information on available mitigation to minimize potential impacts. While some comments suggested that bats could forage in the restored estuarine environment, or shift to other nearby lakes, other comments stated that the Draft EIS did not fully characterize the importance of Capitol Lake to local populations, including the Woodard Bay trestle colony. This colony is located out of the proposed project area in Henderson Inlet, and has been described as the largest known maternity colony in Western Washington. Some of the comments assert that the loss of the constructed freshwater lake habitat would cause substantial negative impacts on the Woodard Bay trestle colony. The Draft EIS did conclude that the loss of the constructed freshwater lake would result in a significant impact on the regional bat population, and specifically on the Woodard Bay bat colony, mainly from the reduction of foraging sites. This conclusion, however, may have been based on a limited body of information sources.

This annotated bibliography is intended to collate and summarize the various sources of information necessary to reevaluate the potential for the Capitol Lake-Deschutes Estuary Project to impact bats, specifically those that roost within the abandoned Woodard Bay trestle. Establishing the full bat assemblage in the project area, identifying components of the ecosystem important to these species, and understanding seasonal variability in demographics and use are important for a full analysis.

Bats in the Pacific Northwest are comparatively understudied relative to populations in the Eastern U.S. and Europe, limiting the information that directly profiles local populations. For this reason, sources reviewed (below) were not limited by geography but instead were also selected if they provide insight on bat genera potentially occurring within the project area. In addition, sources presented here span a diversity of formats, ranging from primary (scientifically reviewed) literature, white papers, poster presentations, to natural history summaries. No personal communications are included.

This annotated bibliography is also intended to allow stakeholders to gain an understanding of the information the analysis is based on, and identify other sources important to the analysis that may not yet be identified.

Sources are organized by geography – those that include data and analyses from the Salish Sea region, and those that are from other regions but focus on applicable bat taxa and/or biology.

Information Sources that Include Data and Analyses from the Salish Sea Region

Bat Conservation International. 2022. About Bats [web application]. Accessed: April 2022. Available: https://www.batcon.org/.

- *Key Words: (various).*
- *Upshot: Resource for various species-specific information such as range maps, natural history information (foraging habitats, habitats, roost and foraging characteristics, migration and other movement information, research references).*

Brigham, R.M., H.D. J.N. Aldridge, and R.L. Mackey. 1992. Variation in Habitat Use and Prey Selection by Yuma Bats, *Myotis yumanensis.* Journal of Mammalogy, Volume 73, Issue 3. 21 August 1992. Pgs. 640–645. Available: https://www.sandiegocounty.gov/content/dam/sdc/pds/ceqa/JVR/AdminRecord/IncorporatedByReference/Section-2-3---Biological-Resources-References/Brigham%20et%20al%201992.pdf.

- *Key Words:* Myotis yumanensis*, habitat use, prey, British Columbia, reproductive, age classes, aquatic insects, diet reflecting changes in availability, river.*
- *Upshot: This study tracked over 100* Myotis yumanensis *during the breeding season and documented all foraging in open habitats over land and low over water. Dietary variation suggests they forage opportunistically on aquatic insects, with changes in diet reflecting changes in availability.*

The study purpose was to assess variation in habitat use and prey selection by *Myotis yumanensis* in British Columbia. It tested the hypothesis that habitat use and resulting prey choice are constant among different reproductive and age classes. They light tagged 115 individuals and observed their foraging activity for a total of 218 minutes on 16 nights from May to September 1989. The four reproductive and age classes (pregnant, lactating, post-lactating, juvenile) all predominantly foraged within open, uncluttered habitats over land and low over water. Dietary variation suggests this species forages opportunistically on aquatic insects with changes in diet reflecting changes in availability.

Burke Museum. 2022. Collections & Research [web application]. Accessed: April 2022. Available: https://www.burkemuseum.org/collections-and-research.

- *Key Words: (various).*
- *Upshot: Resource for various species-specific information – particularly regional species and observations – such as range maps, natural history information (foraging habitats, habitats, roost and foraging characteristics, migration and other movement information, research references).*

Cascadia Research Collective. 2011. Cascadia Research – Winter Bativity in Western Washington - mid-November through mid- March Last update 20 Oct 2011. Available: https://www.cascadiaresearch.org/cascadia-research-bat-work-publications-reports/cascadia-research-winter-bativity-western-washington.

- *Key Words: Bat activity, mid-November through mid- March, California myotis, silver-haired bat.*
- *Upshot: California myotis and silver-haired bats are active throughout the winter (November–March) down to temperatures of around 38°F.*

In 2004–2006, California myotis and silver-haired bats were documented active throughout the winter (November–March). They were observed at some foraging locations where they had been found during the summer – foraging patterns were similar: silver-haired bats forage around the upper canopy of large conifers, and the California myotis were more widespread and in the lower canopy, especially along paths, driveways, and roads. One evening in late 2005, silver-haired bats were detected until 5 hours after sunset when the air temp was 6oC (43oF) and it was dry and calm. Silver-haired bat foraging activity has been detected from a few minutes after sunset on nearly any dry winter evening when the temperature is above approximately 4oC (38–40oF).

Falxa, G. 2004. Rethinking Yuma Bat and Little Brown Bat Foraging Endurance. Cascadia Research Collective, Olympia, WA. 2004 meeting of the Wash. Chapter of The Wildlife Society, Ellensburg, WA. Available: https://nwbats.com/woodard/3_ForagingEndurance_2004_WesternBatWorkingGroup.pdf.

- *Key Words:* Myotis yumanensis, Myotis lucifugus*, maternity roost, Woodard Bay trestle, riparian, aquatic emergent insects, Capitol Lake.*
- *Upshot: This telemetry study tagged and followed 4 bats from a colony of over 3,000 individuals and found that 2 of these bats traveled over 12km to Capitol Lake to forage.*

This study suggests that commonly accepted foraging behavior for small Myotis bats is not applicable in all landscapes, and they apparently have the physical endurance to sustain long bouts of foraging without night roosting. Over 3,000 bats are known to roost in the abandoned Woodard Bay trestle. The maternity colony was monitored with emergence counts from 23 March to 11 October 2003. Researchers mist-netted bats leaving the trestle on 11 nights between 25 April and 21 August, 2003, and a total of 4 bats were fitted with a telemetry tag with the goal of gaining insight into their foraging range. The tagged bats included one that was pregnant, one that was lactating, and two that were post-lactating. Only one bat carried a radio-tag at any one time. One of the radio-tags deployed was defective and could not be detected further than approximately 100m, and only one forage location and one commuting location was obtained from that individual. Two of the radio-tagged bats foraged for long periods without resting or night roosting. All four radio-tagged bats were tracked flying greater than 7 km from their day roost, and two of the bats were found foraging at Capitol Lake, over 12 km from the maternity roost where they were captured. These two bats were tracked to this lake on six consecutive nights (in July and in August). One traveled directly to the lake from the day roost, foraged up to 5.5 continuous hours at the lake, then traveled back to the roost for a total of >6.5 hours "on the wing." These long uninterrupted foraging times may indicate that resources at Capitol Lake are particularly abundant or that competition closer to the trestle from the large colony requires foraging to be dispersed. The sample size of this study will need to be increased to determine the significance of these observations (a high proportion of the colony foraging at Capitol Lake would suggest high-quality foraging habitat is present, a low proportion of the colony foraging at Capitol Lake would suggest dispersed foraging behavior is required).

Falxa, G. 2005. Do Large Colonies Create Long Commutes? Examining Myotis Bat Foraging Distance and Duration. 2005 Western Bat Working Group meeting, Portland, OR. Available: https://nwbats.com/woodard/2_2005_Myotis_commute_poster_final.pdf.

- *Key Words:* Myotis yumanensis, Myotis lucifugus*, maternity roost, Woodard Bay trestle, Capitol Lake.*
- *Upshot: Seven bats were tagged at the trestle, with five being documented traveling to Capitol Lake. Differences in roosting, foraging distances, and foraging destinations were observed, and bats were documented foraging at a diversity of lakes, drainages, and inlets.*

Over 3,000 bats – *Myotis yumanensis* and *M. lucifugus* – are known to roost in the abandoned Woodard Bay trestle, which is a maternity colony. Bats arrive to the trestle in April, have young in early June, and the young become volant in early July. The colony mostly migrates away by September. The colony was monitored from late March to early October 2003 and 2004, using mist nets to catch individuals for telemetry tagging. A total of seven bats were tagged at the trestle, with five documented traveling to Capitol Lake, a distance of over 13km. Two of these bats were tracked to the lake during six consecutive nights (one in July, one in August). Behavioral variability was documented amongst the tagged bats, where differences in roosting, foraging distances, and foraging destinations were observed. Bats were documented foraging at a diversity of lakes, drainages, and inlets. There is mention that monitoring Capitol Lake with acoustic surveys is occurring to better identify species and spatial distribution at this foraging site (no findings were reported). The sample size of this study will need to be increased to determine the significance of these observations (a high proportion of the colony foraging at Capitol Lake would suggest high-quality foraging habitat is present, a low proportion of the colony foraging at Capitol Lake would suggest dispersed foraging behavior is required).

Falxa, G. 2007. Winter Foraging of Silver-haired and California Myotis Bats in Western Washington. Northwest Naturalist. 88:98–100. Autumn 2007. Available: https://nwbats.com/woodard/Falxa_Winter-foraging_NWNaturalist-2007.pdf.

- *Key Words: Silver-haired Bats,* Lasionycteris noctivagans*, California Myotis,* Myotis californicus*, winter activity, Puget Sound, Washington.*
- *Upshot: Silver-haired bats and California Myotis were documented active and foraging in the Puget Sound region during the winters of 2006 and 2007.*

This study documents foraging behavior in silver-haired bats and California Myotis during the winter months in western Washington. Over the course of two winters, visual and acoustic observations of feeding behavior occurred during 16 rainless evenings at six locations near Olympia, Thurston County, WA. The sites were chosen in part because of previous observations of silver-haired bats and California Myotis foraging during summer months. Monitoring was conducted during November through February of 2005/2006 and January through February of 2007. On all 16 evenings that bat activity was monitored, silver-haired bats, California Myotis, or both species were observed flying and foraging. Both species were detected at Priest Point Park in Olympia and at a rural residence 3 km north of the Park. Only one species was detected at the 4 other locations. No other species of bats were detected during the sampling period. Most observations were within 1.5 hour after sunset, but two silver-haired bats were still foraging at Priest Point Park at 23:00 on 21 November 2005, when the air temperature was 6oC. The relatively mild maritime climate of the Puget Sound region may allow some resident bats to use an alternate winter strategy to that of the prolonged dormant periods characteristic of bats that tend to occupy colder sites during winter, such as caves, mines, or those that are inland or at higher elevations. The warmer conditions experienced by bats inhabiting low-elevation areas around Puget Sound may promote more shallow, intermittent torpor and allow bats to arouse on days when insect prey is likely available. Moths and other insects are reported available throughout the winter months in the Puget Sound area, particularly on days and evenings with no rain and mild temperatures.

Falxa, G. 2008. An Overview of an Extraordinary Colony of Myotis Bats [slide-deck]. Cascadia Research Collective, Olympia, Washington. Oral presentation to North American Symposium on Bats, Scranton, PA. Available: https://nwbats.com/woodard/1_Falxa_NASBR_2008_Fri-AM_Extraordinry-colony.pdf.

- *Key Words: midge, Capitol Lake,* Myotis evotis.
- *Upshot: Capitol Lake hosts 13 midge species and has a modified shoreline that is half wooded.*

Capitol Lake hosts 13 midge species and has a modified shoreline that is half wooded. Long commute distances and long hours of foraging observed in this study may indicate sub-optimal conditions: Possible lack of prey abundance; Pacific Northwest evenings are typically cool; lack of secure, suitable roost structures closer to food sources (suggested by tracking data); and other studies observed similar lack of night roosting in M. evotis, in the northern extent of its range.

Hayes, M.P., T. Quinn, and T.L. Hicks. 2008. Implications of Capitol Lake Management for Fish and Wildlife. Prepared by: The Washington Department of Fish and Wildlife. Prepared for: Capitol Lake Adaptive Management Program Steering Committee. 11 September 2008.

- *Key Words: Capitol Lake, invertebrates, Corophium, Tipuloideae, Chironomidae, Typhlocypris, Hydracarina, Trichoptera.*
- *Upshot: A diversity of aquatic invertebrates utilize Capitol Lake, many of which are important to bats.*

A diversity of invertebrates utilize Capitol Lake: Amphipods identified were in the genus Corophium, which occurs mostly in marine and brackish water environments. In Puget Sound, Corophium occurs in the mud to fine sand. Crane flies (superfamily Tipuloideae) are the largest group of flies; larvae of several species are aquatic and make up a significant portion of the biodiversity along the margins of freshwater aquatic habitats. Chironomid midges (family Chironomidae) are a large group of flies. A few Chironomid midge larvae are saline tolerant. Ostracods or seed shrimp (class Ostracoda) are large group of small crustaceans protected by a bivalve-like chitinous or calcareous "shell." Dominant Ostracods in Capitol Lake were identified as belonging the genus Typhlocypris, which are entirely of freshwater obligate benthic-dwelling species. Water mites (suborder Hydracarina) are a large arachnid group of obligate freshwater species. Caddisflies (order Trichoptera) are a large group of small moth-like insects (as adults) with aquatic larvae. A few species are unusual among insects in having larvae restricted to saltwater (marine tidal pools), but all other caddisflies are known use exclusively freshwater habitats.

Myers, P., R. Espinosa, C.S. Parr, T. Jones, G.S. Hammond, and T.A. Dewey. 2022. The Animal Diversity Web [web application]. Accessed: April 2022. Available: https://animaldiversity.org.

- *Key Words:* Myotis yumanensis, Myotis lucifugus*, foraging, ecology, reproduction.*
- *Upshot: This provides sources of natural history information, based on primary literature, for bat species potentially found in the project area.*

NatureServe. 2022. NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Accessed: April 2022. Available: https://explorer.natureserve.org/.

- *Key Words: (various).*
- *Upshot: Resource for various species-specific information such as range maps, natural history information (foraging habitats, habitats, roost and foraging characteristics, migration and other movement information, research references).*

Towanda, T. and G. Falxa. (undated) Emergence and Foraging Patterns of *Myotis lucifugus* and *M. yumanensis* Bats in the Southern Puget Sound Region. The Evergreen

State College. Poster Presentation. Available: https://cascadiaresearch.org/files/2007_TESC_Bat_Poster.pdf.

- *Key Words:* Myotis, Eptesicus, Lasionycteris*, winter, Myotis lucifugus, M. yumanensis, roosting ecology, Puget Sound, winter activity, insects.*
- *Upshot: Two individuals of two species* - Myotis lucifugus *and* M. ymanensis - *were radio-tagged and tracked to document their commute distances and foraging times. Time of initial emergence was predicted by time of sunset and not determined by social cues. M. lucifugus commuted over twice as long for foraging as previously documented – possibly due to nursery roosts being scarce in the area.*

Tobin, A. 2020. What Happens to Bats in the Pacific Northwest Winter? Washington Ecological Services Office, USFWS. Nov. 12, 2020. Available: https://usfws.medium.com/what-happens-to-bats-in-the-pacific-northwest-winter-5c47b4ed2827.

- *Key Words:* Myotis, Eptesicus, Lasionycteris*, winter, roosting ecology, Puget Sound, winter activity, insects.*
- *Upshot: Many Pacific Northwest bats remain in the region during winter where they roost and adjust activity, according to availability of prey species. Bats in Puget Sound tend to be active year-round and forage when conditions are appropriate (i.e., invertebrates are active).*

There are at least 16 bat species in the Pacific Northwest, all of which have their own strategies for surviving winter. For non-migratory species, some live in coastal and lowland Puget Sound areas and are active year-round. The California myotis (*Myotis californicus*) and silver-haired bat (*Lasionycteris noctivagans*) are two species that have been found in the winter months in this area. It is believed the bats can go into torpor in inclement weather to conserve energy, but in periods of good weather, enough insects are available to sustain these populations through the winter. Other species have also been found hibernating in similar spots but in fewer numbers, such as the silver-haired bat, western long-eared myotis (*M. evotis),* Yuma myotis (*M. yumanensis*), big brown bat (*Eptesicus fucus*), and little brown bat (*M. lucifugus)*. It is also thought that many bats will select other places to roost that offer protection and stable yet cool temperatures for hibernation such as tiny crevices in cliffs, talus slopes, or even in root wads. Non-breeding season bat behavior, specifically winter roosting ecology, is not fully understood in the Pacific Northwest and requires additional study.

Washington Department of Fish and Wildlife. 2022. Yuma Myotis (bat) (*Myotis yumanensis*). Species in Washington. Species & Habitats. Accessed: March 2022. Available: https://wdfw.wa.gov/species-habitats/species/myotis-yumanensis#desc-range.

- *Key Words:* Yuma myotis*, forage, beetles, moths, flies, leafhoppers, lacewings, crickets, spiders, harvestmen.*

- *Upshot: Main prey include moths, arachnids, leafhoppers, planthoppers, and beetles.*

Yuma myotis forage on beetles, moths, flies, leafhoppers, lacewings, crickets, spiders, harvestmen, and other invertebrates. The presence of flightless insects in the diet indicates that some prey are gleaned from foliage. Analyses of stomach contents indicate that the main prey include moths, arachnids, leaf and plant hoppers, and beetles in western Oregon and moths and leafhoppers in eastern Oregon. The slow and highly maneuverable flight of this species is well suited to both aerial capture and gleaning of prey from foliage. This, together with the type of echolocation call, suggests that Yuma myotis are adapted for foraging within forests and along forest edges.

Washington Department of Fish and Wildlife. 2022. Little Brown Bat (*Myotis lucifugus*). Species in Washington. Species & Habitats. Accessed: March 2022. Available: https://wdfw.wa.gov/species-habitats/species/myotis-lucifugus#desc-range.

- *Key Words: Emerging aquatic insects, midges, prey, moths, beetles, non-aquatic flies, spiders.*
- *Upshot: Emerging aquatic insects (especially midges) are major prey, but moths, beetles, non-aquatic flies, a variety of other insects, and spiders are also eaten.*

Emerging aquatic insects (especially midges) are major prey, but moths, beetles, non-aquatic flies, a variety of other insects, and spiders are also eaten. Little brown myotis possess low wing loading, low aspect ratios, rounded wing tips, and high frequency echolocation, which give the species maneuverable flight and allow it to specialize on small insects. Foraging is often concentrated over or near water, but also occurs along forest edges, in forests, over lawns and streets, and in other cover types. Feeding is most active during the 2–3 hours after dusk when insect activity often peaks. Most prey is captured in the air and consumed in flight. Nightly foraging movements usually range 1–14 km from day roosts.

Washington Department of Natural Resources. 2002. Woodard Bay Natural Resources Conservation Area Management Plan. March 2002. Available: https://www.dnr.wa.gov/publications/amp_woodard_nrca_mgt_plan.pdf.

- *Key Words: Nursery colony, trestle,* Myotis yumanensis, Eptesicus fuscus, Myotis lucifugus, *population.*
- *Upshot: Multiple species of bats utilize Woodard Bay, including the abandoned trestle.*

Bats represent the second-most diverse group of mammals in Washington State. However, surprisingly little is known about the ecology and life history of this group. The older part of the 2,800-foot-long pier provides roosting habitat for a nursery colony of bats. Species collected to date include *Myotis yumanensis* and *Eptesicus fuscus.* There appears to be a Myotis species present of two different sizes, suggesting a third species present, possibly *Myotis lucifugus.* Use of the pier by bats occurs between March and October, yearly. The population has fluctuated between 1,400 and 650 individuals between 1993 and 1999.

Western Bat Working Group. 2022. Western Bat Species [web application]. Accessed: April 2022. Available: http://wbwg.org/western-bat-species/.

- *Key Words: (various).*
- *Upshot: Resource for various species-specific information such as range maps, natural history information (foraging habitats, habitats, roost and foraging characteristics, migration and other movement information), research references.*

Hayes, G., and G. J. Wiles. 2013. Washington Bat Conservation Plan. Washington Department of Fish and Wildlife, Olympia, Washington. 138+viii pp. Available: https://wdfw.wa.gov/sites/default/files/publications/01504/wdfw01504.pdf.

- *Key Words: (various).*
- *Upshot: Resource for various species-specific information – particularly regional species and observations – such as range maps, natural history information (foraging habitats, habitats, roost and foraging characteristics, migration and other movement information), research references.*

Information Sources that include Analyses of Bat Taxa and/or Biology Applicable to the Study Area

Ahlen, I., H.J. Baagøe, and L. Bach. 2009. Behavior of Scandinavian Bats during Migration and Foraging at Sea. Journal of Mammalogy. 90 (6). Pgs. 1318-1323. Available: https://academic.oup.com/jmammal/article/90/6/1318/898402.

- *Key Words: Behavior, Chiroptera, flight altitude, foraging, migration, sonar, offshore, coast, insects, crustaceans, sea (ocean), fall, spring,* Myotis, Pipistrellus, Nyctalus, Eptesicus, Vespertilio, Plecotus*, summer.*
- *Upshot: A diversity of bat species migrate and forage over marine waters, where they target insects and surface water crustaceans.*

Migration and foraging bat behavior were studied over the sea by direct observations and acoustic recording. Eleven species (of a community of 18 species) were observed flying over the ocean up to 14 km from the shore. All bats used sonar during migration flights at sea, often with slightly lower frequencies and longer pulse intervals compared to those used over land. The altitude used for migration flight was most often <10 m above sea level. Bats must use other sensory systems for long-distance navigation, but they probably use echoes from the water surface to orient to the immediate surroundings. Both migrant and resident bats foraged over the sea in areas with an abundance of insects in the air and crustaceans in the surface waters. During 2005 and 2006, 4,051 observations were made, and 10 different species were documented over the sea. They regularly documented bats foraging over the ocean in almost all survey areas. Foraging behavior was especially common in areas with high abundance of insects in the air or crustaceans on the water surface. The abundance of prey at sea varied with area. Myotis spp. were observed touching the water surface, presumably gaffing prey, where net samples collected no insects but an abundance of crustaceans in the sea surface – it was assumed that these bats were feeding on the crustaceans. There was no apparent correlation between insect abundance and sea-bottom structure or distance from coast. Insect abundance was probably related to wind conditions and water currents. During periods with low easterly winds, insects of many kinds drifted over the water surface. On these occasions, insect density increased to the south. Insects included chironomids of marine origin but also terrestrial insects probably flying or drifting from the Baltic Republics or Russia. Migrating bats took advantage of the presence of abundant prey and foraged for shorter or longer periods depending on prey availability. The abundance of food offshore already was used by many bat species in midsummer, well before the onset of the migration period.

Ancillotto L., J. Rydell, V. Nardone, and D. Russo. 2014. Coastal Cliffs on Islands as Foraging Habitat for Bats. Acta Chiropterologica. 16 (1). Pgs. 103-108. Available: https://bioone.org/journals/acta-chiropterologica/volume-16/issue-1/150811014X683318/Coastal-Cliffs-on-Islands-as-Foraging-Habitat-for-Bats/10.3161/150811014X683318.short.

- *Key Words: Coastal cliffs, foraging habitat, island, habitat selection, four bat species,* Barbastella.
- *Upshot: Multiple species of bats utilize and may prefer coastal cliffs for foraging habitat.*

Small islands usually show simplified ecosystems with limited availability of suitable foraging habitats for bats; thus, habitat selection on islands may differ compared to the mainland. Habitats that are marginal on the mainland may be important on islands. The island of Capri (SW Italy) consists, to a large extent, of steep limestone cliffs and Mediterranean shrubland, with virtually no forests or other habitats preferred by bats on the mainland. This study tested the hypothesis that in resource-limited systems, such as islands, habitats generally deemed of minor value for bat foraging, such as cliffs, may become important. The study conducted an acoustic survey of bats in Capri, comparing their use of Mediterranean shrubland and limestone cliffs. Results indicated that cliffs provided the preferred foraging habitat in four of the five species tested. Noticeably, even the barbastelle bat (*Barbastella barbastellus*), normally considered a forest specialist, selected coastal cliffs as foraging habitat. The observations indicate that the paucity of foraging habitats on islands may strongly alter the habitat use by bats. This has important implications for conservation of bats in insular environments.

BSG Ecology. 2015. Coastal Habitat use by Bat Species. Technical Report. Available: http://www.bsg-ecology.com/wp-content/uploads/2015/10/Coastal-habitat-use-by-bat-species.pdf.

- *Key Words: Coastal, saltmarsh, rocky shore, sandy shore,* Myotis*, coastal cliff vegetation, strandlines, foraging.*
- *Upshot: Coastal habitat – rocky shore, sandy shore, coastal cliff vegetation, strandline saltmarsh – is important habitat for bats.*

In comparison to other habitats, such as woodland, there have been few applied empirical studies into bat activity at coastal sites. Research worldwide indicates that certain coastal habitat types could be important for bat ecology, particularly coastal cliffs and saltmarsh. Coastal sites are dynamic and increasingly vulnerable to human development. The study identified bat species present around the coastal sites of Swansea Bay (UK), locations of high bat activity at coastal areas, and compared differences in bat activity between sandy shore and rocky shore habitats. At least five species of bats were found to use coastal sites. Species identified included common pipistrelle, soprano pipistrelle, noctule, serotine, and Myotis species. Coastal habitat use appears to be significantly greater at the rocky shore than the sandy shore habitat, with coastal cliff vegetation and strandlines used as foraging sites. Coastal habitat is an important habitat type for supporting bats.

Fletcher, J.J. 2017. Habitat Use and Species Assemblage of Bats in a Northeastern Coastal Plain Ecosystem. State University of New York, College of Environmental Science and Forestry. ProQuest Dissertations Publishing. Degree Year: 2017. 10642963. Available: https://www.proquest.com/openview/8ad6ccc1039213394612c5cda4958ac7/1?pq-origsite=gscholar&cbl=18750.

- *Key Words: Seashore, coastal plain, habitat use,* Myotis*, species assemblage, summer.*
- *Upshot:* Myotis *species were found in relatively high numbers in coastal habitats, and availability of suitable habitat or competition with other species were not limiting factors.*

Bat habitat use in the Northeast has been well studied; however, research has focused on interior locations, leaving coastal areas relatively understudied. Cape Cod National Seashore (CCNS) is a coastal plain peninsula where the understanding of bat habitat associations is limited to historical data. Sites were acoustically sampled during the summer within CCNS during 2015 and 2016 to quantify the local and landscape factors associated with habitat use and species assemblage. Interspecific effects of co-occurrence among bat species to understand factors influencing habitat use were examined. Coastal bats were found to use sites similar to interior populations despite differences in dominant vegetation types. Myotis were found in relatively high numbers, and availability of suitable habitat or competition with other species were not limiting factors. Continued acoustic monitoring on CCNS should extend beyond summer habitat use and coordinate mist netting to improve power to draw inferences.

Gonsalves, L., S. Lamb, C. Webb, B. Law, and V. Monamy. 2013. Do Mosquitoes Influence Bat Activity in Coastal Habitats? Wildlife Research. 40(1). Pgs. 10-24. 30 January 2013. Available: https://doi.org/10.1071/WR12148.

- *Key Words: Coastal saltmarsh, aquatic and terrestrial arthropods, mosquito, foraging, edge habitat,* Vespadelus.
- *Upshot: Proportional bat feeding activity was greatest in saltmarsh – prey abundance was positively correlated with total bat activity only in the open saltmarsh where an absence of clutter would maximize prey detectability and thus availability.*

Conservation of insectivorous bat populations requires appropriate management of foraging habitats and the prey resources they sustain. Endangered coastal saltmarsh communities support a diverse range of aquatic and terrestrial arthropods, including the saltmarsh mosquito (*Aedes vigilax*), an important vector of mosquito-borne viruses and a potentially important prey resource for insectivorous bats. Prey detectability by bats is limited with low-frequency echolocation, particularly in cluttered habitats that may render abundant *A. vigilax* populations unavailable to some bat species. Whereas prey abundances were generally greatest in saltmarsh and forest habitats, bat activity was greatest in the forest habitat. However, proportional feeding activity was greatest in saltmarsh. Prey abundance was positively correlated with total bat activity only in the open saltmarsh where an absence of clutter would maximize prey detectability and thus availability. Positive correlations between *A. vigilax* abundance and bat activity, across all habitats, were restricted to bats of the *Vespadelus* genus, which are small-sized bats that employ high-frequency echolocation suitable for detection of small prey along edges.

Gonsalves L., B. Law, C. Webb, and V. Monamy. 2012. Are Vegetation Interfaces Important to Foraging Insectivorous Bats in Endangered Coastal Saltmarsh on the Central Coast of New South Wales? Pacific Conservation Biology. 18 (4). Pgs. 282-292. Available: https://www.researchgate.net/publication/287239408_Are_Vegetation_interfaces_important_to_foraging_insectivorous_bats_in_endangered_coastal_saltmarsh_on_the_Central_Coast_of_New_South_Wales.

- *Key Words: Saltmarsh, vegetation, edge habitat, linear habitat, edge zones, insect abundance, foraging.*
- *Upshot: Multiple bat species were documented foraging in linear habitats along saltmarsh, particularly along edge zones between saltmarsh and edging transitional vegetation.*

Conservation of insectivorous bats and their habitats is of increasing concern in Australia, and linear elements in the landscape form important foraging habitats for many species. Only recently has the use of endangered coastal saltmarsh habitat by bats been documented. Vegetation adjoining saltmarsh provides bats with linear elements that may be used while foraging and commuting to patches of high insect abundance. Acoustic detectors were used to investigate whether individual species and total bat activity along seaward and landward saltmarsh edges was different than the interior of the saltmarsh. Four taxa accounted for greater than 80% of all bat activity in each zone with similar taxa recorded in both edge and interior zones. However, significantly more bat activity was recorded in edge zones. While differences in microhabitat use by individual species were also found, bat morphology did not account for the observed differences. Conservation managers of saltmarsh and adjoining habitats should consider potential impacts of management actions on foraging bats and their prey. Retention of strips of edge vegetation may help to balance the conservation requirements of endangered coastal saltmarsh habitats and the foraging insectivorous bat populations they sustain.

Mas, M., C. Flaquer, H. Rebelo, A. López-Baucells. 2021. Bats and Wetlands: Synthesizing Gaps in Current Knowledge and Future Opportunities for Conservation. First published: 18 February 2021. Available: https://onlinelibrary.wiley.com/doi/epdf/10.1111/mam.12243.

- *Key Words: bats, wetlands, data-gap, literature review, prey, fresh water.*
- *Upshot: Although it is generally acknowledged that wetlands are important for bats, this relationship has been only lightly studied.*

Wetland areas have decreased by up to 33% globally over the past 10 years, threatening the biodiversity they support and essential ecosystem services they provide. Despite this, the importance of wetlands for bat conservation and the consequences of losing these habitats are not comprehensively understood. Through a systematic literature review, they quantified the knowledge gaps regarding bats in wetlands by: (1) assessing research trends over time; (2) evaluating research biases in geography, themes, species, seasons, and methodology; (3) creating the 'bat Knowledge Index' (bKI), a standard indicator for measuring how well-studied bats in wetlands are per country; (4) compiling and summarizing the ecological responses of bats to wetlands; and (5) assessing how bat researchers perceive the role of wetlands for bat conservation. Strong similarities between the reviewed studies and the bat researchers' perceptions were found; however, although 75% of respondents considered wetlands important for bat conservation, they rarely studied these habitats. Most of the studies took place in developed countries, leaving critical gaps in countries where wetlands are rapidly decreasing. Research topics were found to be biased toward habitat selection and species inventory, with many topics only superficially explored. There was also an important seasonal bias, resulting in many unanswered questions during energetically demanding periods for bats (e.g., migration). However, constantly evolving technological developments, such as bat lures and tracking devices, might aid new studies in these habitats. Up to 66% of studies reported that wetlands benefit bat activity or species richness, mainly because of high prey densities and the availability of fresh water. However, the low number of studies and all the identified research gaps make 'bats and wetlands' a largely underexplored ecological interaction between a poorly studied animal taxon and an increasingly threatened habitat.

Maslonek, M.L. 2010. Bat use of Created and Natural Wetlands. Graduate Theses, Dissertations, and Problem Reports. Number 2966. Available: https://researchrepository.wvu.edu/etd/2966.

- *Key Words: wetland mitigation, open water pond, freshwater emergent, bats, indicator of constructed wetland function.*

- *Upshot: association was found between wetland mitigation and bat use – landscape characteristics influenced both presence and relative activity of observed bat species.*

Compensatory wetland mitigation is a common practice to account for wetland losses due to dredging and filling under the Clean Water Act, but successful replacement of function is rarely achieved. Small, isolated wetlands also receive no federal protection and are usually not included in accounts of losses. Although the latest reports show an increase in wetlands for the first time, this is due in large part to voluntary construction of open water ponds, while the loss of freshwater emergent wetlands continues to decline. Research on the wildlife functions of wetlands has focused on plants, invertebrates, avian, or amphibian species. But wetlands also are important for bat foraging habitat because most insects depend on water for some part of their life cycle. Bats could serve as a mammalian indicator of constructed wetland function due to their size, mobility, and ease of acoustic monitoring. Despite this connection, there is a lack of studies focusing on bats and wetlands in the Mid-Atlantic and Midwest, and few have occurred elsewhere. 79 constructed and natural wetlands in western Pennsylvania and eastern Ohio were assessed for the presence of bats using acoustic monitoring. A theoretic model tested the response of bats to wetland design and landscape based on the following: wetland origin, age, size, pH, distance to highway, and areas within the surrounding landscape of forest, urban, open water, barren, wetland, and edge density. For all species except for eastern pipistrelles (*Pipistrellus subflavus*), landscape characteristics influenced both the presence and relative activity of observed bat species. The model incorporated wetland size as well as landscape parameters, and received support for most species, with differences among species based on wing morphology and habitats. Within supported models, surrounding wetlands in the landscape had the greatest influence on most bat species. Big brown bats (*Eptesicus fuscus*) were influenced by barren and open areas, while eastern red bats (*Lasiuris borealis*) were influenced by agriculture. Wetlands created in a landscape with an overall lack of wetlands and less edge may be particularly important for all species of bats, regardless of wing morphology. Wetlands of all sizes, even small ones not afforded federal protection, can be vital foraging areas for bat species. The wetland origin and abiotic characteristics received no support, suggesting that placement within the landscape may be the most important consideration for bats. Because of the association of bats with wetlands, relative ease of acoustic monitoring, and importance of wetlands to mammals in general, bats may be good candidates to develop as a mammalian indicator for wetland function.

Menzel, J.M., M.A. Menzel, J.C. Kilgo, and W.M. Ford. 2005. Bat Response to Carolina Bays and Wetland Restoration in the Southeastern U.S. Coastal Plain. September 2005. Wetlands 25(3):542-550. Available: https://www.researchgate.net/publication/227005474_Bat_response_to_Carolina_bays_and_wetland_restoration_in_the_southeastern_US_Coastal_Plain.

- *Key Words: Restoration, bays, bat activity, wetland.*
- *Upshot: Significantly more bat activity was documented after restoration than prior to restoration for all but one species in the treatment bays.*

Bat activity in the southeastern United States is concentrated over riparian areas and wetland habitats. The restoration and creation of wetlands for mitigation purposes is becoming common in the Southeast. Understanding the effects of these restoration efforts on wetland flora and fauna is thus becoming increasingly important. Because bats (Order: Chiroptera) consist of many species that are of conservation concern and are commonly associated with wetland and riparian habitats in the Southeast (making them a good general indicator for the condition of wetland habitats), they monitored bat activity over restored and reference Carolina bays surrounded by pine savanna (*Pinus* spp.) or mixed pine-hardwood habitat types at the Savannah River site in South Carolina. To determine how wetland restoration efforts affected the bat community, they monitored bat activity above drained Carolina bays pre- and post-restoration. Their results indicate that bat activity was greater over reference (i.e., undrained) than drained bays prior to the restorative efforts. One year following combined hydrologic and vegetation treatment, however, bat activity was generally greater over restored than reference bays. Bat activity was also greater over both reference and restored bays than in random, forested interior locations. They found significantly more bat activity after restoration than prior to restoration for all but one species in the treatment bays, suggesting that Carolina bay restoration can have almost immediate positive impacts on bat activity.

Salvarina, I. 2016. Bats and Aquatic Habitats: a Review of Habitat use and Anthropogenic Impacts. First published: 05 January 2016. Available: https://onlinelibrary.wiley.com/doi/10.1111/mam.12059.

- *Key Words: aquatic habitat, foraging, drinking, use.*
- *Upshot: Most studies on bats and aquatic habitats have been conducted in Europe or in North America and they show, directly or indirectly, how bats use aquatic resources.*

Many bats use aquatic habitats for foraging and for drinking water. Interactions between aquatic and terrestrial systems are important for understanding food web dynamics and for conserving species and ecosystems. Therefore, they examined the data available on bats' use of aquatic habitats. The objectives of the review were to evaluate the importance of aquatic resources for bats and to identify the effects that eutrophication, water pollution, and other anthropogenic impacts on water bodies have on bats. Most studies on bats and aquatic habitats have been conducted in Europe or in North America. They show, directly or indirectly, how bats use aquatic resources. Acoustic survey is the most common technique employed to assess habitat use by bats, although some researchers have used radio telemetry or other methods. *Myotis daubentonii* is the most commonly studied species. Within this topic, research does not tend to be focused more on threatened species. The effects of water pollution and eutrophication on bats remain unclear: different effects are reported for different species and in different areas. More studies are needed from Africa, South America, and Asia, regions for which few data are available, as well as from arid regions where fresh water is a limited resource.

Parker, K.A. Jr, B.T. Springall, R.A. Garshong, A.N. Malachi, L.E. Dorn, A. Costa-Terryll, R.A. Mathis, A.N. Lewis, C.L. MacCheyne, T.T. Davis, A.D. Rice, N.Y. Varh, H. Li, M.D. Schug,

and M.C. Kalcounis-Rueppell. 2019. Rapid Increases in Bat Activity and Diversity after Wetland Construction in an Urban Ecosystem. Wetlands (Wilmington, N.C.), 39(4), 717–727. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6764773/.

- *Key Words: Chiroptera, Conservation, Management, Fresh Water, Piedmont, Bioindicators, Eptesicus fuscus, Winter, Spring.*
- *Upshot: Bats use constructed wetlands in urban ecosystems similarly to other habitat settings – increases in bat activity, diversity, and species richness occurred within 1 year of wetland construction.*

Wetland construction can mitigate the biodiversity and water quality losses associated with reduced natural wetland coverage. While beneficial effects of wetland construction for bats have been observed in natural and rural settings, the effects of wetland construction on bats in an urban ecosystem are less understood. They used passive acoustic monitoring to measure bat activity levels and diversity at two constructed wetlands and two control sites on the University of North Carolina Greensboro campus, in Greensboro, North Carolina. They monitored all four sites before and after wetland construction. Pre-wetland construction, there were few differences in bat activity and community structure at the sites. After wetland construction, they observed greater activity, attributable to all species recorded, at wetland sites compared to control sites. Species diversity and species richness were also higher at wetland sites compared to control sites. When comparing the same sites before and after wetland construction, both bat activity and species richness increased after construction, but the effects were seen in winter and not spring. Their results demonstrate that bats use constructed wetlands in urban ecosystems similarly to other habitat settings. Increases in bat activity, diversity, and species richness occurred within 1 year of wetland construction.

Laegdsgaard, P., V. Monamy, and N. Saintilan. 2006. Investigating the Presence of Threatened Insectivorous Bats on Coastal NSW Saltmarsh Habitat. Wetlands (Australia). 22 (1). Pgs. 29-41. Available: https://www.researchgate.net/publication/268395439_Investigating_the_presence_of_threatened_insectivorous_bats_on_coastal_NSW_saltmarsh_habitat.

- *Key Word: Saltmarsh, coast, island, insect, foraging.*
- *Upshot: Multiple bat species – and species of insect prey – were documented in saltmarsh habitat, underscoring the importance of this habitat to supporting bat populations.*

This paper documents the presence of a number of species of insectivorous bats over saltmarshes in temperate Australia. Bat activity, detected using an Anabat Recorder, was particularly high at Kooragang Island on the Hunter River. A detailed survey of insect diversity and abundance on Kooragang Island demonstrated a diverse range of insects corresponding to published data on the diet of bat species recorded. The study suggests that saltmarsh is likely an important source of insect prey for many bat species.

Shute, K.E., S.C. Loeb, and D.S. Jachowski. 2021. Seasonal Shifts in Nocturnal Habitat Use by Coastal Bat Species. The Journal of Wildlife Management. 85(5):964–978. DOI: 10.1002/jwmg.22060. Available: https://www.srs.fs.usda.gov/pubs/ja/2021/ja_2021_loeb_003.pdf.

- *Key Words: Saltmarsh, habitat, seasonal habitat use, summer, winter, upland forest, bottomland forest, fields, ponds,* Myotis*,* Perimyotis*,* Lasiurus.
- *Upshot: Saltmarsh is used by bats for foraging in summer and winter.*

Sensitivity of bats to land use change depends on their foraging ecology, which varies among species based on ecomorphological traits. Additionally, because prey availability, vegetative clutter, and temperature change throughout the year, some species may display seasonal shifts in their nocturnal habitat use. In the Coastal Plain of South Carolina, the northern long-eared bat (*Myotis septentrionalis*), southeastern myotis (*M. austroriparius*), tri-colored bat (*Perimyotis subflavus*), and northern yellow bat (*Lasiurus intermedius*) are species of conservation concern that are threatened by habitat loss. This study identified characteristics of habitat used by these species during their nightly active period, and compared use between summer and winter. Acoustic surveys were conducted at 125 sites during May–August and at 121 of the same 125 sites December–March 2018 and 2019 in upland forests, bottomland forests, fields, ponds, and saltmarsh, and used occupancy models to assess habitat use. Myotis bats used sites that were closer to hardwood stands, pine stands, and freshwater year-round. Tri-colored bat habitat use during winter included bottomland forests, fields, and ponds more than saltmarsh and upland forests. During summer and winter, northern yellow bats used sites close to freshwater and saltmarsh. Additionally, during summer they used fields, ponds, and saltmarsh more than upland and bottomland forests, but in winter they used bottomland forests, fields, and ponds more than upland forest and saltmarsh. Results highlight important land cover types for bats in this area (e.g., bottomland forests, ponds, and saltmarsh), and that habitat use changes between seasons. Accounting for and understanding how habitat use changes throughout the year will inform managers about how critical habitat features may vary in their importance to bats throughout the year.

Scott, T.F. 2008. Bat Species Richness and Edge Habitat Use on a Coastal Island in South Carolina. Coastal Carolina University. Legacy Thesis, Electronic Theses and Dissertations. 98. Available: https://digitalcommons.coastal.edu/etd/98.

- *Key Words: Lower coastal plain, edge habitat, pine, hardwood, foraging, fields, island.*
- *Upshot: Edge habitats are important for supporting both insects and a diversity of bat species that feed upon them.*

The Lower Coastal Plain (LCP) of South Carolina is home to possibly 12 species of bats. Bats in the Southeastern U.S. exhibit similarities in their call characteristics including but not limited to the visual representation of their calls. Identification of bats inhabiting the coastal plain by acoustic monitoring is difficult and the results may be unreliable. Bat species richness was assessed during the summer of 2007 using both capture and acoustic monitoring techniques. Bat calls along two general edge habitat types (pine and hardwood) were recorded to determine if bat activity differed significantly between edge habitats. Pine edge habitats are less vegetatively complex than hardwood edge habitats, and bat activity was predicted to be greater along pine edges than hardwood edges. Larger bats may have greater difficulty foraging and flying in dense and cluttered vegetation than smaller bat species, and navigation through such areas may be more energetically costly than navigating through less dense and open-air areas. Insect dry mass along edge habitats was collected to determine if bat activity was dependent upon insect prey availability. Six species of bats were identified through capture and acoustic monitoring. Bat activity (based on the number of recorded bat calls) did not differ significantly between the two edge types. Data did not support the prediction that the number of recorded bat calls would be greater along pine edges than recorded along hardwood edges. Bat activity along hardwood edge habitats was greater than expected, suggesting that canopy-free areas like the fields on Spring Island may be important areas for bats. Unlike many other studies, bat activity was not dependent upon insect mass.

Allen, H. 1994. The Mammals of Texas - Online Edition (On-line). Accessed: November 22, 1999. Available: http://www.nsrl.ttu.edu/tmot/myotyuma.htm.

- *Key Words:* Myotis yumanensis, Myotis lucifugus*, foraging, ecology, reproduction.*
- *Upshot: This provides sources of natural history information, based on primary literature, for bat species potentially found in the project area.*

Whitaker, J. 1996. National Audubon Society Field Guide to North American Mammals. New York: Alfred A. Knopf, Inc.

- *Key Words:* Myotis yumanensis, Myotis lucifugus*, foraging, ecology, reproduction.*
- *Upshot: This provides sources of natural history information, based on primary literature, for bat species potentially found in the project area.*

Kunz, T., E. Anthony, and W. Rumage. 1977. Mortality of Little Brown Bats Following Multiple Pesticide Applications. Journal of Wildlife Management 41 (1977): 476. Available: https://www.semanticscholar.org/paper/Mortality-of-Little-Brown-Bats-Following-Multiple-Kunz-Anthony/9458e3c818decfb2454e374881e06ca90ec47825.

- *Key Words: little brown bats,* Myotis lucifugus*, nursery colony, mortality, pesticide.*
- *Upshot: Human-caused mortality of little brown bats is less severe than anticipated due to seasonal timing.*

This study documents the mortality of little brown bats (*Myotis lucifugus*) at a nursery colony in southern New Hampshire in a 2-year period following multiple applications of pesticides (DDT, chlordane) for extermination. Mortality among adult females was greatest in the second summer (principally in the parturition period) following the last pesticide application. Two major peaks of mortality occurred in young bats, one soon after birth and another as they reached adult size.

Significant age differences in mortality were observed between the first and second years after spraying. The percentage of young bats dying as they approached adult size was highest in the second year. Mortality was nearly nine times higher in young than among adult bats in the first year, whereas proportionately more adults died in the second year. They suggest that the prolonged and latent mortality of bats following pesticide applications increases the short- and long-term health risk to humans and therefore necessitates the reevaluation of current extermination practices. Most efforts to document accumulation of pesticide residues in insectivorous bats arose out of concern for declining bat populations. These studies assumed that the principal route of pesticide entry was via the food chain, with bats as "non-target" species. The application of DDT, chlordane, and similar compounds directly on bats or their roosting places has become common practice in the name of "public health" and "vermin control." With the exception of a follow-up study, the effectiveness of these compounds for such purposes is virtually unknown. Agencies authorizing the use of pesticides for extermination usually assume that once they have been applied, the vermin have been controlled and the related public health problems resolved. They challenge this assumption.

Fenton, M., R. Barclay. 1980. *Myotis lucifugus*. Mammalian Species, 142: 1-8.

- *Key Words:* Myotis lucifugus*, foraging, ecology, reproduction.*
- *Upshot: This provides sources of natural history information, based on primary literature, for bat species potentially found in the project area.*