SY-01 SYNTHESIS AND INTEGRATION OF INFORMATION ON RESOURCES IN THE LOWER SKAGIT RIVER INTERIM REPORT

SKAGIT RIVER HYDROELECTRIC PROJECT FERC NO. 553

Seattle City Light

Prepared by:
Cramer Fish Sciences

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Initial Study Report

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List of Acronyms and Abbreviations

AFS .....American Fisheries Society
CFS .....Cramer Fish Sciences
City Light.....Seattle City Light
Ecology .....Washington State Department of Ecology
FERC.....Federal Energy Regulatory Commission
FRI .....flood recurrence interval
GIS .....Geographic Information System
ILP.....Integrated Licensing Process
ISR .....Initial Study Report
LP.....licensing participant
NWFSC.....Northwest Fisheries Science Center
PME .....protection, mitigation, and enhancement
Project .....Skagit River Hydroelectric Project
RM .....river mile
RSP .....Revised Study Plan
SHSTMP .....Salmon Habitat Status and Trend Monitoring Program
SL.....sea level
SLP.....sea level pressure
SST.....sea surface tempature
USR.....Updated Study Report
UWI.....upwelling index

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1.0 INTRODUCTION

The SY-01 Synthesis and Integration of Information on Resources in the Lower Skagit River (Synthesis Study) is being conducted in support of the relicensing of the Skagit River Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 553, as identified in the Revised Study Plan (RSP) submitted by Seattle City Light (City Light) on April 7, 2021 (City Light 2021). On June 9, 2021, City Light filed a "Notice of Certain Agreements on Study Plans for the Skagit Relicensing" (June 9, 2021 Notice)[1] that detailed additional modifications to the RSP agreed to between City Light and supporting licensing participants (LP) (which include the Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, National Marine Fisheries Service, National Park Service, U.S. Fish and Wildlife Service, Washington State Department of Ecology [Ecology], and Washington Department of Fish and Wildlife). The June 9, 2021 Notice included agreed to modifications to the Synthesis Study.

In its July 16, 2021 Study Plan Determination, FERC approved the Synthesis Study without modification.

This interim report on the 2021 study efforts is being filed with FERC as part of City Light's Initial Study Report (ISR). City Light will perform additional work for this study in 2022 and include a report in the Updated Study Report (USR) in March 2023.

[1] Referred to by FERC in its July 16, 2021 Study Plan Determination as the "updated RSP."

2.0 STUDY GOALS AND OBJECTIVES

The goal of the study is to compile, analyze, and summarize available data and studies on anadromous fish resources using the Skagit River watershed, characterize factors affecting these populations, develop conceptual life history models of each population, and develop hypotheses to understand potential impacts of the Project and other contributing factors in the watershed. Existing information on watershed-wide contributing factors will then be updated and integrated with the results of studies being conducted as part of the Integrated Licensing Process (ILP) to determine the major factors affecting each target species, which may further inform preferred watershed-based measures and/or longer-term adaptive management processes for protecting and enhancing target anadromous salmonid populations in the Skagit River. The recommended target species are Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*), Sockeye Salmon (*Oncorhynchus nerka*), Chum Salmon (*Oncorhynchus keta*), Pink Salmon (*Oncorhynchus gorbuscha*), Bull Trout (*Salvelinus confluentus*), and steelhead (*Oncorhynchus mykiss irideus*). Based on the preliminary data review and consultation with LPs in the December 2021 Synthesis Study Work Group Meeting, the target species for the Synthesis Study has been clarified to include Pacific Lamprey (*Lampetra tridentata*).

Study requests raise hypotheses that Project operations may detrimentally affect conditions in the lower Skagit River downstream of the Sauk River and in the estuary related to water quality, habitat availability, wood and sediment transport, riparian and floodplain conditions, and other factors that may impact the life stages of anadromous fish resources using the lower river, delta, and estuary. As noted in the RSP, quantification of Project-related effects on anadromous fish resources in the lower Skagit River represents a significant scientific challenge given the multitude of factors interacting with resources and processes in the lower Skagit River. This study is intended to summarize and synthesize available data and existing analyses by others (e.g., recovery plans, peer-reviewed and gray literature) that have investigated the conditions of these resources in the study area to date to inform potential studies and analysis during the second year of study. A list of some of these factors are listed as potential topics of interest below.

- Geomorphology (e.g., geomorphic change, channel migration and incision; aquatic habitat; side channel/off channel connection; floodplain connectivity; substrate and sediment; wetlands; sediment transport; and large wood inventories);
- Landforms;
- Water quality;
- Aquatic primary and secondary productivity;
- Fish and aquatic habitat (e.g., species limiting factors; habitat quality and quantity; salmonid population trends);
- Riparian vegetation and wetlands;
- Available modeling tools (e.g., hydraulic, biological, geomorphologic); and
- Other watershed and regional activities and land uses (e.g., forestry/logging, agriculture, commercial/industrial, shoreline development, levees, shoreline hardening, floodplain development and encroachment, irrigation/diking, urban landscapes).

Per the June 9, 2021 Notice, additional commitments related to the goals and objectives of the Synthesis Study include:

- City Light will perform additional field studies in 2022 to fill data gaps that are not addressed in the Synthesis Study or other studies below the Sauk River confluence.
- City Light will consolidate the results of the Synthesis Study and baseline data collected in other studies that extend below the Sauk River confluence in the Synthesis USR in an attempt to identify Project effects below the Sauk River confluence.

A full list of City Light's commitments from the June 9, 2021 Notice with respect to the Synthesis Study is included in Section 6.2 of this study report.

The Synthesis Study is subdivided into four steps: (1) data compilation; (2) data analysis; (3) identification of factors affecting the target species by reach and life stage; and (4) identification of key uncertainties for each of these factors and the data/information needed to address/reduce the uncertainties. Each step is briefly described below and expanded upon in the Methodologies Section of this study report. The review and synthesis of existing information and available information from other studies being undertaken under the ILP will be used to identify any additional field data collection needs related to investigating the Project's effects on anadromous salmonids in the reach below the Sauk River. The results of this study will help establish a broader understanding of potential preferred protection, mitigation, and enhancement (PME) measures to protect and improve the target species and/or initiate consensus-based studies to increase the understanding of specific key factors.

Step 1: Data Compilation

The first step of the Synthesis Study is to assemble and review relevant and available information to characterize the status of each target species and physical and ecological attributes of important habitats for individual salmonid life stages of these target species in the lower Skagit River system. This study report focuses on progress towards this step of the Synthesis Study.

Step 2: Data Analysis

Relevant information collected during data compilation will be analyzed to develop life-history-based conceptual models of each of the Skagit River target anadromous fish species using the lower river, delta, and estuary. To the extent possible and practical, linkages will be explored between species abundance/productivity and land and water uses, physical and ecological watershed processes, habitat conditions in the lower Skagit River and delta/estuary, hatchery operations, ocean conditions, and the effects of these factors on anadromous fish resources.

Step 3: Life Stage Factors Affecting Target Species

Using a life-history framework, hypotheses about key in-river and delta/estuary factors thought to be of greatest importance to each of the target anadromous fish populations in the Skagit River watershed will be derived based on the work conducted in the data compilation and data analysis steps. Factors considered would include those identified above in the Topics of Interest. Potential relationships between these key factors affecting anadromous fish resources in the Skagit River

below the Sauk River confluence and Project operations will be identified and verified based on the work conducted in Steps 1 and 2.

Step 4: Identification of Key Uncertainties

Based on the information and data developed and analyzed in the first three steps, this step includes identifying areas where further data are necessary to understand the key mechanisms and Project operations affecting species and their respective in-river, delta, and estuary life stages. Where large uncertainties and/or data gaps exist related to analyzing Project effects on key factors affecting anadromous fish resources, specific studies to reduce uncertainties and/or fill data gaps will be identified.

2.1 Key Questions

As noted in the RSP, the goals of this study are to compile, summarize, and analyze available data and studies on anadromous fish resources using the Skagit River watershed, characterize factors affecting these populations, develop conceptual life history models of each population, and develop hypotheses to understand potential impacts of the Project and other contributing factors in the watershed. The preliminary approach described in this study report is designed to address several key questions that address the goals of the Synthesis Study, including:

- What is the condition of resources in the lower Skagit River?
- What are the contributing factors to resource conditions in the lower Skagit River?
- What data gaps and research or monitoring needs might limit our ability to describe how Project operations influence conditions in the lower Skagit River?

To understand the condition of resources in the lower Skagit River, the Synthesis Study will directly address this question by developing an inventory and archive of available data for the lower Skagit River study area. Once extracted and compiled, these data will be used to describe the condition of resources in the lower Skagit River study area based on the best available information. This information will then support identifying the contributing factors to resource conditions in the lower Skagit River through development of conceptual life history models for anadromous salmonids that integrate factors affecting survival from one life stage to another.

As noted in the RSP, quantification of Project-related effects on anadromous fish resources in the lower Skagit River represents a significant scientific challenge given the multitude of factors interacting with resources and processes in the lower Skagit River. The data inventory and conceptual life history models developed by this study intend to support identification of data gaps and monitoring needs that currently limit our ability to describe how Project operations influence resource conditions in the lower Skagit River in the context of other factors that influence resources. In addition, this study will support the identification of key uncertainties for hypotheses related to potential Project-related impacts or contributing factors and their influence on resource conditions or life stage transitions that could be addressed by additional research or monitoring.

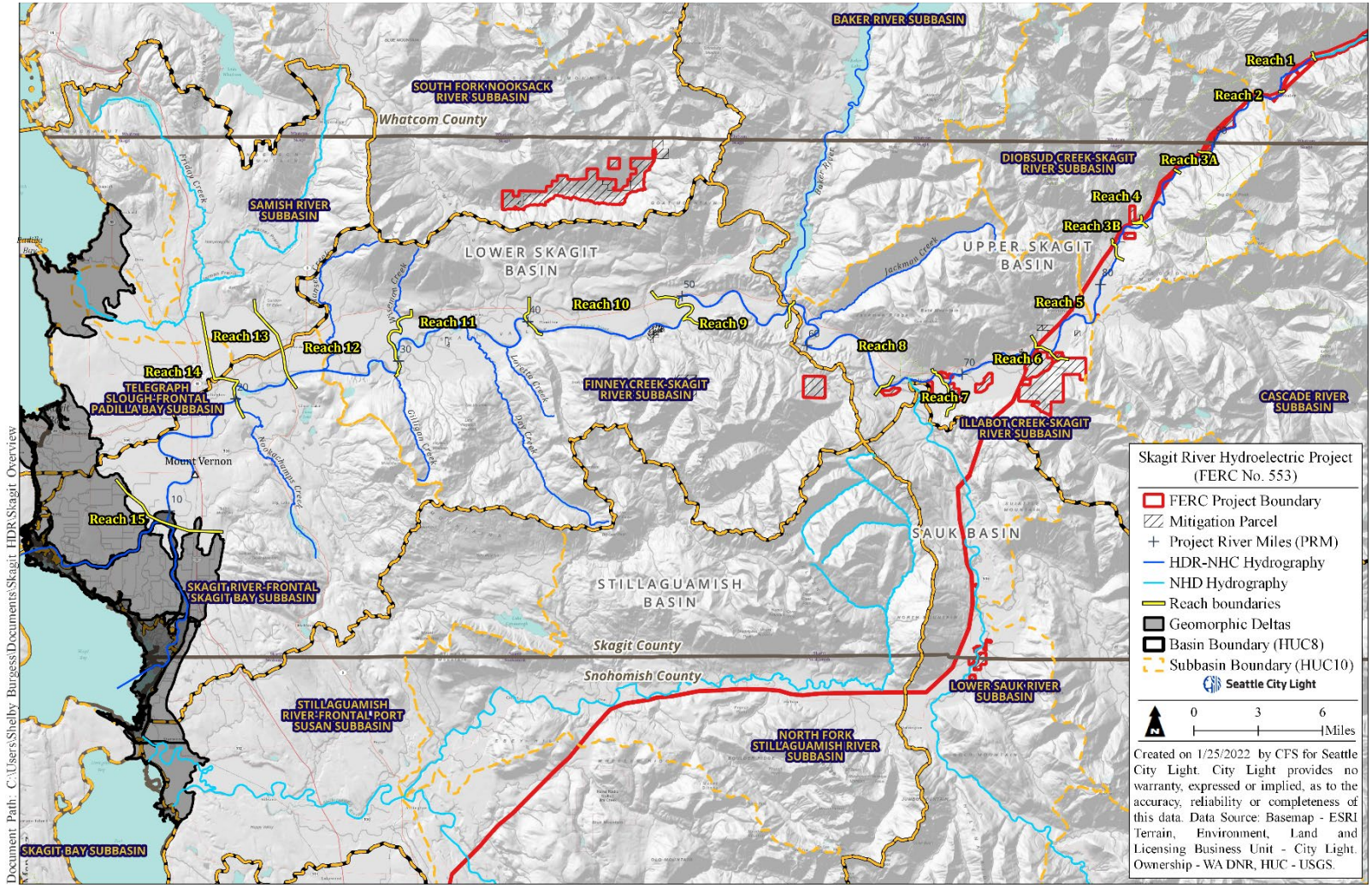
3.0 STUDY AREA

The study area for the Synthesis Study is the Skagit River from the Sauk River confluence to the Skagit delta and estuary (City Light 2021). Several large tributaries that flow into the lower Skagit River study area were also identified in the study plan, including the Baker River, Jackman Creek, Day Creek, Gilligan Creek, Loretta Creek, Hansen Creek, Wiseman Creek, and Nookachamps Creek. Based on the preliminary data review and consultation with LPs in the December 2021 Work Group Meeting, the study area for the Synthesis Study has been clarified to include the following extent:

- The lower mainstem Skagit River from the Sauk River confluence to Skagit Bay;
- Large tributaries to the lower Skagit River including Baker River, Jackman Creek, Day Creek, Gilligan Creek, Loretta Creek, Hansen Creek, Wiseman Creek, and Nookachamps Creek;
- The Sauk River and its confluence reach with the mainstem Skagit River;
- The geomorphic Skagit River delta including the Swinomish delta, North and South Fork Skagit River deltas, and the northern portion of the Stillaguamish River delta; and
- Skagit Bay and Padilla Bay.

This preliminary study area is shown in Figure 3.0-1 and is described in more detail here. Details on how the geographic information is used in the Synthesis Study are provided in Section 4.0 of this study report. Within the mainstem Skagit River, reaches will be consistent with the geomorphic reaches delineated by Riedel et al. (2020) and will include Reach 7-13 (Figure 3.0-1). Large tributaries considered were identified in the RSP and potentially provide unregulated inputs to the lower Skagit River that can attenuate potential Project impacts in the study area (e.g., see Connor and Pflug 2004). The Sauk River also provides a source of unregulated flow and inputs to the lower Skagit River study area and was included in this study area based on feedback from the December 2021 Synthesis Study Work Group Meeting.

For the Skagit River delta and its estuary, the delta is considered to include the geomorphic deltas of the North Fork and South Fork Skagit River distributaries, the Swinomish River delta, and the northern portion of the Stillaguamish River delta. This extent is consistent with the Skagit River System Cooperative's delta extent for the Skagit River Chinook Recovery Plan (Beamer et al. 2005) and the boundaries adopted by the National Oceanic and Atmospheric Administration's Salmon Habitat Status and Trends Monitoring Program (Beechie et al. 2017; Stefankiv et al. 2019) and Puget Sound Partnership's Common Indicators and Vital Sign reporting boundaries for the Skagit River delta (Hall et al. 2019). For the estuary, the Skagit Bay and Padilla Bay and associated nearshore and neritic habitats are considered to be the freshwater mixing and transition zone for the Skagit River and its distributaries.



Note: Labeled reaches are based on Riedel et al. (2020), and geomorphic delta boundaries are based on the Northwest Fisheries Science Center (NWFSC) Salmon Habitat Status and Trend Monitoring Program (SHSTMP) delta boundaries and the Skagit River System Cooperative's delta boundary.

Figure 3.0-1. Proposed study area for the Synthesis Study that includes the lower mainstem Skagit River from the confluence of the Sauk River (Reach 7) downstream to the geomorphic Skagit Delta, large tributaries that flow into the lower Skagit River including the Sauk River, and Skagit Bay and Padilla Bay.

4.0 METHODS

4.1 Step 1: Data Compilation

A preliminary approach was developed to complete Step 1: Data Compilation and was presented to LPs in a work group meeting convened on December 15, 2021. Comments from LPs were requested by January 15, 2022 to support refinement of the proposed approach to meeting the study objectives and are integrated into the approach described in this study report.

Step 1 will consist of identification, screening, and summarizing relevant data sources as well as extraction of quantitative data. Identified sources will be screened for relevant information and annotated bibliographies will be developed for all relevant sources. City Light will focus on a subset of sources identified as most relevant during a pre-screening of references (Tier 1 Sources) and develop annotated bibliographies and data inventories to support Steps 2-4. Annotated bibliographies for certain geomorphic studies will be coordinated with the GE-04 Skagit River Geomorphology Between Gorge Dam and the Sauk River Study (Geomorphology Study) team, given both studies include synthesis of information for the lower Skagit River (City Light 2022e).

The following describes the preliminary approach developed to complete Step 1: Data Compilation and support completion of Steps 2-4 of the study. The preliminary approach for data compilation includes the following steps that are described in more detail in this section:

- Identifying and compiling potentially relevant sources;
- Screening and attributing sources for relevant information;
- Summarizing available information; and
- Extracting quantitative data.

4.1.1 Identifying and Compiling Sources

A combination of sources identified in comments to and outlined in the RSP, data sources from previous synthesis studies conducted by Cramer Fish Sciences (CFS; Roni et al. 2008; Roni et al. 2014; Hillman et al. 2016; CFS 2019; Hall et al. 2019), direct communication with relevant co-managers and data stewards, web searches, and references cited in identified sources (to be conducted during screening) will be used to discover potentially relevant information for the Synthesis Study.

A preliminary list of sources was developed based on sources identified in the RSP and previous CFS syntheses studies and was provided to LPs during the December 2021 Synthesis Study Work Group Meeting to support discovery of additional sources not included in this preliminary list. After sources from the RSP and previous syntheses studies were compiled, two web searches using Google Scholar were performed in December 2021, using a combination of geographic, topical, and species search terms:

(1) Skagit AND (Chinook OR Pink OR Sockeye OR Chum OR Coho OR steelhead OR Bull Trout) AND (river OR estuary or floodplain) AND (habitat OR riparian OR geomorphology OR sediment OR water quality OR restoration OR flow OR flow

management OR flow regulation OR hydrology OR climate change OR model OR land use OR limiting factors OR status and trends); and

(2) Sauk River OR Baker River OR Jackman Creek OR Day Creek OR Gilligan Creek OR Loretta Creek OR Hansen Creek OR Wiseman Creek OR Nookachamps Creek AND (Chinook OR Pink OR Sockeye OR Chum OR Coho OR steelhead OR Bull Trout) AND (river OR estuary or floodplain) AND (habitat OR riparian OR geomorphology OR sediment OR water quality OR restoration OR flow OR flow management OR flow regulation OR hydrology OR climate change OR model OR land use OR limiting factors OR status and trends).

The first search focused on the mainstem Skagit River, while the second search focused on large tributaries and the Sauk River. During the first search, the first 20 pages of results were compared against the sources already identified to discover additional, potentially relevant, sources. The first 10 pages of results from the second search were reviewed and compared to previously identified sources to discover additional relevant sources.

Additional sources will be discovered during screening of references cited within the identified sources as described below. All identified sources will be compiled into a reference database and attributed with information on the source as described below, with digital copies (if available) archived for screening. An archive of digital copies will support this study and future studies by making references readily available in a central location.

4.1.2 Screening and Attributing Sources

A relational database was developed to inventory sources and the information they provide to support the Synthesis Study objectives and Steps 2-4. This relational database currently contains a table with information on the sources (tbl_Source), a table to inventory data or information provided by the source (tbl_Data), lookup tables for values that can be attributed to the sources (lkp_Source), and the data identified during screening of the source (lkp_Topics, lkp_Species, and lkp_Reaches).

4.1.3 Source Table and Source Information

The values used to attribute sources in the source table (tbl_Source) are briefly described here and a full list of fields and values is provided in Attachment A. The source table includes the following fields:

- SourceID (sequential numeric value based on order of entry into database);
- Citation (American Fisheries Society [AFS] style citation for source);
- CitationID (unique ID for source that concatenates SourceID and Citation);
- PubYear (publication year);
- Type (source type like journal, report, book, future study);
- Status (e.g., draft, final);
- Reference (full reference for source in AFS format);
- Permissions (e.g., public, restricted);

- ReviewStatus (status of screening and data inventory);
- Format (e.g., PDF, website, dataset); and
- Notes (general notes for source or review status).

This information serves as an inventory of potential sources and provides the basis for a relational database, with CitationID linking the source to the inventory of data contained within it, supporting the ability to filter information based on a number of potentially useful attributes. For example, data could be filtered to only journal or peer-reviewed publications for more robust analyses or filtered to identify data from more recent studies based on the year of publication.

4.1.4 Data Inventory Table and Screening

Identified sources will then be screened for information relevant to the Synthesis Study topics of interest, target species and life stages, study area, and whether the source provides quantitative, spatial, or Project impact data. Given that each source may contain a range of potentially relevant information, the data table was designed to allow multiple records for each source in the data inventory table (tbl_Data). The data inventory table contains the following fields:

- CitationID (unique ID for source in source table);
- KeyWord (concatenated value of topics and key words);
- Species (species or NA if not related to species);
- LifeStage (life stage(s) or NA if not related to species);
- Reach (geomorphic reach or spatial extent);
- QuantData (Yes/No);
- SpatialData (Yes/No);
- ProjectImpacts (Yes/No); and
- Notes (general notes field used to describe the data or findings).

Topic and key words used to identify information provided by sources are described in Attachment A. Topics were used as a high-level category to classify information and group key words and include the following values:

- Geomorphology and Landforms;
- Water Quality and Productivity;
- Modeling Tools;
- Land Use and Cover; and
- Fish and Habitat.

A list of key words was developed within each topic that provide a higher resolution classification of information available from each source. For example, the Fish and Habitat topic includes key words for habitat (e.g., riparian, limiting factors, barriers), fish (e.g., periodicity, abundance, survival), and monitoring (e.g., restoration, abundance, biotelemetry). A preliminary list of 96 key

words was developed to support data inventory, and these are provided in Attachment A. Separate records will be created for each relevant key word identified for each source during screening.

4.1.5 Data Flags and Screening

The topics and key words assigned to each source will also be attributed with data flags to identify which target species, life stages, and reaches the information is related to. The data flags are described in more detail in Attachment A but are described briefly here. For sources with data for target species, separate records will be created for each species for the following target species:

- Chinook Salmon;
- Coho Salmon;
- Sockeye Salmon;
- Chum Salmon;
- Pink Salmon;
- Bull Trout;
- Steelhead; or
- Pacific Lamprey.

For example, if a source contains data on the abundance of Chinook and Coho salmon, two records will be created with the [KeyWord] field = "Fish, abundance" and [Species] = "Chinook" and [Species] = "Coho." If the source does not contain information on target species or the data are not related to target species (e.g., water quality data), the [Species] field will be populated as "NA" to indicate that the data are not associated with a particular target species. For records that are related to a target species, the relevant life stage(s) will be entered into the [LifeStage] field with the following values:

- Migration (adult migration upriver, including holding);
- Spawning (adult spawning);
- Adult outmigration (for iteroparous species);
- Incubation (egg incubation in substrate);
- Rearing (juvenile rearing in freshwater habitats);
- Overwintering (juvenile overwintering in freshwater habitats);
- Outmigration (juvenile outmigration downstream from freshwater habitats);
- Estuary rearing and emigration (juvenile rearing, transition, and migration through estuary habitats);
- Nearshore rearing and emigration (juvenile rearing and migration through nearshore habitats, including pocket estuaries); or
- Ocean (adult maturation in ocean habitats).

Life stages were classified into these general categories, but the data may be related to multiple life stages or span several stages. For example, smolt to adult return rates are calculated from freshwater outmigration abundance and adult spawner or escapement abundance estimates and would span the "Outmigration" to "Migration" or "Spawning" life stages listed above. Therefore, ranges of life stages may be used to attribute records in the data inventory table.

Spatial information will also be recorded using data flags that can be associated with records for the data inventory to indicate the spatial extent of the data. The reach information will be based on the study area defined in this study report, which will include the following extents:

- Reaches 7-12 (geomorphic reaches as defined in Riedel et al. (2020) that include the lower mainstem Skagit River);
- Reach 13 (the geomorphic delta for the Skagit River including the North and South Fork Skagit River distributaries, Swinomish Channel, and the northern portion of the Stillaguamish River delta);
- Skagit Bay and Padilla Bay (nearshore habitats including pocket estuaries, beach, and neritic habitats);
- Sauk River (data specific to the Sauk River tributary to the Skagit River); and
- Upstream Reach 7 (data specific to the Skagit River watershed but only available for reaches upstream of the study area).

Many previous, ongoing, or future studies related to target fish species in the reaches and reservoirs upstream of the study area could be linked to abundance and demographic patterns of target species in the study area. For example, steelhead and Bull Trout are capable of expressing resident, adfluvial, and anadromous life histories with plasticity in expression of these life histories given the absence of fish passage barriers (Kendall et al. 2014). Therefore, studies of potential distribution, abundance, or genetics (e.g., FA-04 Fish Passage Technical Studies Program, FA-06 Reservoir Native Fish Genetics Baseline Study, FA-07 Reservoir Tributary Habitat Assessment; City Light 2022b, 2022c, and 2022d) could be related to downstream abundance and demographic patterns for these species. Similarly, studies of water quality or hydrological parameters in the upper basin can be related to patterns and conditions in the study area or used to define boundary conditions for the lower Skagit River study area. Therefore, data from some sources focused on reaches upstream of the study area may be inventoried to support future data analysis of conditions in the study area.

Sources that were screened and then determined to not provide information specific to the study area were flagged as either "Out of System" or "Out of Study Area" in the [ReviewStatus] field in the source table and will be archived as "Other Sources." This includes general ecology or biology references that synthesize information from many systems and are not specific to the Skagit River but may be used to support development of conceptual life history models and hypotheses for factors effecting resource conditions. Sources that represent previous reports or publications that are covered by the most recent publication will also be archived as "Other Sources" as these sources may provide additional detail that could be used in later steps of the study.

Data flags will be used to identify whether the data are quantitative, spatial, or related to Project impacts. The quantitative data flag will be used to specifically identify information that can be used to support Step 2: Data Analysis. Records flagged as providing quantitative data will provide the baseline for identifying data to be extracted to support the data analysis. The spatial data flag will be used to identify if the data are available in a format that can be used in spatial analyses (e.g., spatial outputs from a hydrodynamic model or distribution of large woody debris). For Project impacts, records will be flagged if the source provides data that are linked to potential Project impacts (e.g., flow regulation and aquatic habitat) and may include studies with a pre- or post-impact design (e.g., changes in conditions with pre and post agreement flows), modeling (e.g., simulated conditions with flow regulation scenarios), or correlative analyses (e.g., trends in abundance correlated with trends in flow regulation metrics).

4.1.6 Summarizing Available Information

For Step 1: Data Compilation, the data inventory developed during screening of sources as outlined in the previous section will be used to generate summaries of available information. This can be done based on any number of topics of interest, key words, species, life stages, reaches, or quantitative, spatial, or Project impact data. This will support development of data analysis plans and identification of data gaps to be addressed by future monitoring or data from other systems. An annotated bibliography will also be developed for each source that will provide a high-level summary table for the source (full reference, source type, topics of interest, key words, species, life stages, and whether the source provides quantitative, spatial, or Project impact data), a summary paragraph describing the overall study or data, and a paragraph summarizing the information relevant to the Synthesis Study objectives. The annotated bibliography will be provided in Attachment B, and will be organized into three sections:

- Tier 1 (sources that provide extensive information and data that are directly relevant to the Synthesis Study objectives);
- Tier 2 (sources that provide some information relevant to the Synthesis Study objectives); and
- Other Sources (ongoing or future studies, older annual reports of studies covered by more recent versions, and out of system or out of study area sources that can provide reference information).

For this interim report, examples of annotated sources are provided in Attachment B. This section will be completed for all identified sources as sources are screened. Similarly, the results section will focus on preliminary summaries based on the number of identified references for this interim report but will be updated with summaries based on data inventories when Step 1: Data Compilation is completed. Tier 1 and Tier 2 Sources are listed in Attachment C. Other Sources will be listed in "Attachment D: Other Sources" to support future studies or Steps 2-4 of the Synthesis Study depending on the identified data gaps.

4.1.7 Extracting Quantitative Data

Available quantitative data will be identified and summarized in the annotated bibliographies to support identification of data that can be extracted to support Steps 2-4. Protocols and data tables for data extraction will be refined as part of the data analysis step. For this interim report, a general description of considerations for data extraction to support data analysis is provided. Like the data

inventory table, tables to store quantitative data will be added to the relational database to support data analysis. Quantitative data will be extracted from sources or obtained through direct communication with authors or data stewards where possible or required. Data that can only be obtained from figures will be extracted based on the figure axis scales using plot digitizing tools like WebPlotDigitizer (Rohatgi 2021). This provides a more quantitative estimate of data from figures than visual estimation and can be used to efficiently extract data when tables are not available from the source or direct communication. All data extracted from figures will be saved with the associated figure in an archive for reference or future use.

The quantitative data will be linked to the source using the [CitationID] and tables will be designed based on the relevant data identified during the data inventory developed in Step 1: Data Compilation. The table(s) may include a combination of fields that contain the value of a metric as well as fields that describe the type of metric (e.g., fish abundance or spawning habitat), metric units (e.g., count or area), sample size (e.g., number of samples used to develop metric), and variance measures (e.g., standard deviation or standard error of a mean). These data are important for meta-analyses of data from multiple sources and will allow analyses to account for differences in sample sizes and variance from multiple studies (see Foote et al. 2020). In addition, fields may be included that indicate which species (e.g., Chinook or Coho), life stage (e.g., juvenile outmigration or adult spawning), life history (e.g., yearling, parr migrant, fry migrant), and temporal period or coverage (e.g., years, seasons, months, or weeks and whether data are describing the beginning, peak, or end of periods for metrics describing periodicity).

Project impact data will also be extracted, but additional fields may be needed to describe how metrics or responses are related to Project operations (e.g., pre- or post-changes in flow management). Similarly, monitoring data may include pre- or post-monitoring for actions like restoration, or model simulations and outputs may consider multiple scenarios that would require additional fields to describe the quantitative data. Spatial data may be archived but the focus of this synthesis will be to identify spatial data sources to support the data inventory and extract final data summaries from spatial data rather than develop a spatial database of spatial data. For example, metrics like pools per mile or pool habitat area would be extracted from mapping data of aquatic landforms as opposed to shapefiles of habitat units.

4.2 Step 2: Data Analysis

Relevant information identified during Step 1 Data Compilation will be extracted and analyzed to develop life-history-based conceptual models of each of the Skagit River target anadromous fish species using the lower river, delta, and estuary. City Light will coordinate with the technical sub-group coordinating the development of periodicity tables as part of the FA-02 Instream Flow Model Development Study (City Light 2022a) to ensure that periodicities are consistent among studies. To the extent possible and practical, linkages will be explored between species abundance/productivity and land and water uses, physical and ecological watershed processes, habitat conditions in the lower Skagit River and delta/estuary, hatchery operations, ocean conditions, and the effects of these factors on anadromous fish resources.

4.3 Step 3: Life Stage Factors Affecting Target Species

A life-history framework will be used to describe hypotheses about key in-river and delta/estuary factors thought to be of greatest importance to each of the target anadromous fish populations in

the Skagit River watershed based on the results of Step 1: Data Compilation and Step 2: Data Analysis. In addition to data driven results, hypotheses identified in screened sources as well as those identified by LPs will be considered and discussed in work group meetings. In this way, a transparent and inclusive framework can be provided for conceptual life history models that consider a number of potentially informative hypotheses and alternative hypotheses for complicated relationships between and among life stage transitions and Project impacts or other contributing factors. This analysis will be organized by species and life stage and will include citations to develop robust and well documented conceptual life history models. The analysis will follow the general template provided in the RSP.

4.4 Step 4: Identification of Key Uncertainties

High priority areas of uncertainty will be identified where further data are needed to understand the key mechanisms and Project operations affecting species and their respective in-river, delta, and estuary life stages. This will include data gaps that can be derived directly from analysis of the data inventory as well as from analysis of quantitative data and development of the conceptual life history models. Collectively, this analysis will support the identification and prioritization of near or long-term research or monitoring needs to address key uncertainties in the conceptual life history models.

5.0 PRELIMINARY RESULTS

The following results represent progress towards completing Step 1: Data Compilation. Summaries of available data and data gaps, annotated bibliographies, extraction of quantitative data, analysis of data, and development of conceptual life history models will be developed as Steps 1-4 are completed. Therefore, this study report represents preliminary results, and any summaries are subject to change as Steps 1-4 are completed. For this study report, the results are focused on the number of sources identified and progress towards developing data inventories and annotated bibliographies. In addition, annotated bibliographies for certain geomorphic studies are being coordinated with the GE-04 Geomorphology Study team because both studies include synthesis of information for the lower Skagit River (City Light 2022e).

A total of 286 potentially relevant sources were identified from a combination of references in the RSP and other relicensing documents as well as previous CFS synthesis studies. This list was provided to LPs during the December 2021 Synthesis Study Work Group Meeting, and two additional sources have been provided by LPs in response to the preliminary list, to date. An additional 32 potentially relevant sources were identified from web searches completed in December 2021. As of filing of this study report (March 2022), a total of 414 potential sources have been identified and digital copies have been archived for 317 of them. This includes sources identified from the above steps as well as sources found within references cited in sources that have been screened thus far and results of preliminary web and database searches.

Most sources identified thus far (59 percent) are reports (or white and gray literature) with 20 percent of the potential sources being journal articles (Figure 5.0-1). A total of 12 future studies have been identified thus far that could provide information relevant to the Synthesis Study objectives. These include multiple Estuary and Salmon Restoration Program Learning Projects and other relicensing studies identified in the RSP (City Light 2021) and June 9, 2021 Notice that specifically include overlaps in study area extent or objectives with the Synthesis Study. However, the future studies identified thus far represent a preliminary list and the results of all studies will be considered, and targeted searches for future studies will be completed as part of the Synthesis Study.

Of the sources identified, a total of 11 sources have been screened with data inventory and annotated bibliographies completed as a proof of concept for the relational database for this study report. Data identified from this preliminary screening included data for all primary topics of interest (Figure 5.0-2), with most data inventoried being related to fish and habitat (76 percent). Among these data, data has been identified related to Chinook Salmon, steelhead, Pink, and Chum thus far (n=131), as well as data related to all anadromous species (n=21), with 36 records unrelated to target species. Among the records related to target species, inventoried data includes all life stages and data that span multiple life stages. Spatially, the preliminary inventory includes data that span all reaches of the study area, with some data that include areas upstream of the study area (n=126) as well as potentially relevant data that are only available for areas upstream of the study area (n=5). These include models, methods, or data (e.g., survival estimates) that could inform conditions in the lower Skagit River study area.

Among the data inventoried thus far, 90 percent (173/188) are flagged as quantitative data that could be used to support data extraction and data analysis. Spatial data were identified in 30 percent (62/188) of the inventoried data, and 30 percent (62/188) of the inventoried data were related to potential Project impacts in the lower Skagit River study area. As noted previously, these summaries are based only on the sources that have been screened at the time of this study report. They are only intended to show progress towards completing Step 1: Data Compilation and provide an example of how the data inventory can be summarized to support data extraction and Steps 2-4 of the Synthesis Study.

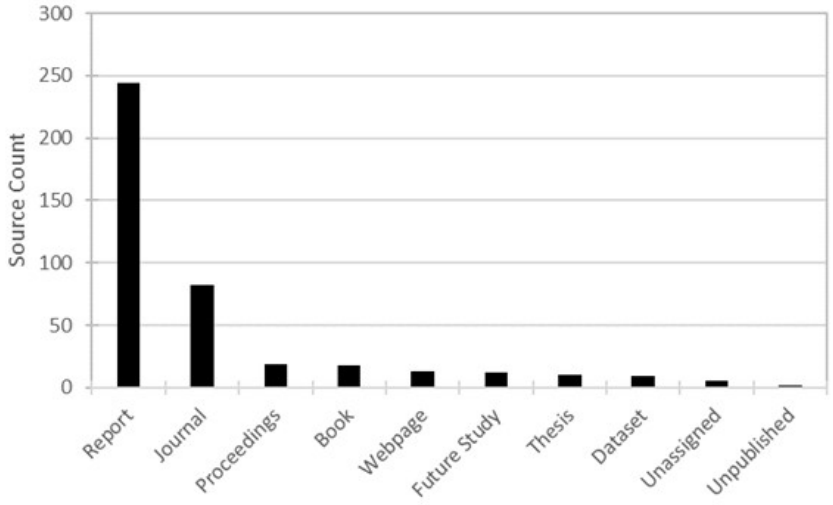


Figure 5.0-1. Count of potentially relevant sources by source type that have been identified to date.

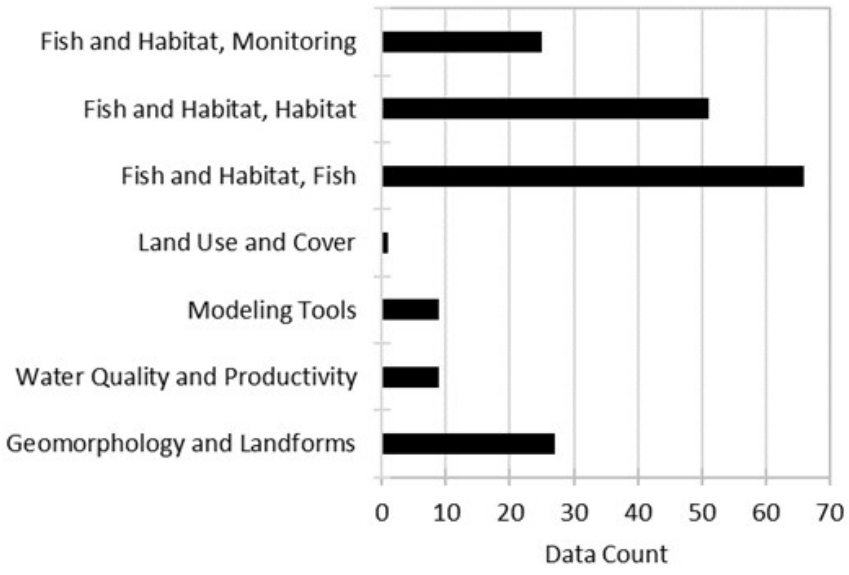


Figure 5.0-2. Count of records added to data inventory from sources screened to date by primary topic of interest.

6.0 SUMMARY

6.1 Summary

This section summarizes the preliminary approach to address Steps 2-4 of the Synthesis Study and development of conceptual life history models to support identification of data gaps and inform hypotheses on resource conditions in the lower Skagit River. The approach for Steps 2-4 will be refined in coordination with LPs through additional work group meetings, comments on this study report, and based on the findings of Step 1: Data Compilation. Work group meetings will be scheduled as needed to review the outcomes of Step 1 and to engage LPs in Steps 2-4 to provide opportunities for discussion of factors affecting life stage survival, hypotheses and mechanisms, and Project impacts as well as data gaps and key uncertainties. Key components of Step 1 are planned to be finished between June and September 2022, with Steps 2-4 being initiated after the annotated bibliographies and data inventories are completed for at least the Tier 1 Sources. Steps 2-4 can be implemented in tandem and can be completed between June and November 2022 to support LP engagement and completion of the USR in March 2023.

- **Step 1: Data Compilation (November 2021 – September 2022, with Tier 1 Sources completed by June 2022)** – Identified sources will be screened for relevant information and annotated bibliographies will be developed for all relevant sources. Based on pre-screening efforts, City Light has identified 101 Tier 1 sources, 159 Tier 2 Sources, and 88 Other Sources.
- **Step 2: Data Analysis (June 2022 – March 2023) –** This step will begin after annotated bibliographies and data inventories are completed for at least the Tier 1 Sources, and this data analysis step can be done in tandem with Steps 3-4. Relevant information identified during Step 1 Data Compilation will be extracted and analyzed to develop life-history-based conceptual models of each of the Skagit River target anadromous fish species using the lower river, delta, and estuary.
- **Step 3: Life Stage Factors Affecting Target Species (June 2022 – March 2023) –** This step will begin after annotated bibliographies and data inventories are completed for at least the Tier 1 Sources. Relevant information identified during Step 1 Data Compilation will be extracted and analyzed to develop life-history-based conceptual models of each of the Skagit River target anadromous fish species using the lower river, delta, and estuary.
- **Step 4: Identification of Key Uncertainties –** Based on the information and data developed and analyzed in the first three steps, Step 4 will be completed in coordination with Steps 2-3 and will identify areas where further data are needed to understand the key mechanisms and Project operations affecting species and their respective in-river, delta, and estuary life stages.

6.2 Synthesis Study Modifications Identified in the June 9, 2021 Notice

The June 9, 2021 Notice noted six items of discussion related to implementation of this Synthesis Study. The status of each is summarized in Table 6.2-1.

Table 6.2-1. Status of Synthesis Study modifications identified in the June 9, 2021 Notice.

Study Modifications identified in the June 9, 2021 Notice	Status
City Light acknowledges Project effects in the Lower Skagit River, which includes the area from the confluence of the Skagit River and the Sauk River downstream to the mouth of the Skagit River estuary, can be detected.	City Light acknowledges that such effects can be detected.
City Light will perform the SY-01 synthesis study as proposed in RSP.	The Synthesis Study is being implemented as proposed in the RSP with modifications as described within this study report.
City Light will perform additional data field studies in year 2 to fill data gaps in SY-01 that are not addressed in the synthesis study or in other studies below the Sauk River (identified above).	On hold awaiting the results on the desktop analysis portion of the Synthesis Study. A determination of data collection needs as part of the Synthesis Study will be made in Q4 2022.
City Light will consolidate results of the synthesis study and baseline data collected in other studies that extended below the Sauk in the SY-01 study report to identify Project effects below the Sauk.	On-going action item to be completed as study results become available and in coordination with this Synthesis Study.
Results of the study will be shared with the LPs and will inform the long-term ecosystem adaptive management and monitoring program and mitigation for project impacts below the Sauk.	On-going action item to be completed as study results become available and in coordination with this Synthesis Study.
City Light will clarify the study plan to indicate that data collection in the Lower River will be addressed through other study plans.	Incorporated into the Synthesis Study effort.

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

The following variances from and proposed modification to the FERC-approved study plan have been identified below. The study area description has been revised to include the Sauk River, larger geomorphic delta extent (including Swinomish and portions of the Stillaguamish River delta), and nearshore habitats in Skagit Bay and Padilla Bay, based on preliminary data review and comments from LPs during the preliminary Synthesis Study Work Group meeting. These adjustments to the study area are designed to better capture the extent of habitat that support target species and life stages produced by the Skagit River (e.g., geomorphic delta extent and nearshore habitats) as well as capturing major sources of potential variation of influences on resource conditions in the lower Skagit River (e.g., the Sauk River).

In addition, based on preliminary data review and consultation with LPs in the December 2021 Synthesis Study Work Group Meeting, the target species for the Synthesis Study has been expanded to include Pacific Lamprey.

On June 30, 2021, City Light convened a meeting with LPs to set the agenda for the first Synthesis Study Group meeting. During that meeting, LPs expressed an interest in modifying the study's approach (as described in Section 2.7 of the RSP) to provide for a study team to execute the study and convene regular work group meetings to collaborate with LPs. Following this meeting and FERC's issuance of the Study Plan Determination on July 16, 2021, City Light identified a qualified principal investigator to begin implementation of the study in the fall of 2021. Given the delayed timing of study implementation, City Light proposes to modify the Synthesis Study implementation schedule as described in Section 6.1 of this study report. City Light intends to work with LPs in 2022 to review the data compiled (Step 1), analyze the data (Step 2), identify life stage factors affecting target species (Step 3), and determine data collection needs as part of this study in the fourth quarter (September - December) 2022.

8.0 REFERENCES

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SYNTHESIS AND INTEGRATION OF INFORMATION ON RESOURCES IN THE LOWER SKAGIT RIVER INTERIM REPORT

ATTACHMENT A

DATA SOURCE ATTRIBUTES

This Attachment provides a list of source classifications, topics and keywords, and data flag values that can be used to attribute and categorize sources and data identified in Step 1 of the Synthesis Study. Collectively, these attributes are intended support identification of sources that can be used to support Steps 2-4 of the Synthesis Study. The following tables provide a preliminary list of attributes for source classification, topics and keywords, and data flags for review to support refinement of the attributes used to categorize sources.

SOURCE CLASSIFICATIONS

A simple classification framework was developed to help identify sources with relevant information based on a suite of criteria. Information on the year, type, status, and format of the source information will be recorded. The following table provides a preliminary list of attributes for the classification of sources, as well as a description of the proposed values for classifying sources identified in the Synthesis Study.

Table A-1. Preliminary list of attributes for the classification of sources.

Field	Values	Description
Citation ID	ID + AFS Citation	A unique sequential ID number based on order of entry concatenated with an intext citation in AFS format (Author and year)
Year	YYYY	Year of publication or production
	TBD	For future studies
Type	Journal	Peer reviewed journal publication
	Report	Project report or memo
	Book	Book or book chapter
	Proceeding	Conference or symposium proceedings, abstract, or presentation
	Thesis	Graduate thesis or dissertation
	Webpage	Online data source/portal, webpage
	Unpublished	Unpublished data or information
	Dataset	Standalone dataset
	Future study	Upcoming or ongoing study with relevant results
Status	Draft	Source or publication is in draft form
	Final	Source or publication is in final form
	TBD	Used for future studies
Format	PDF	PDF obtained
	Website	Source is a website (archive PDF copy for synthesis?)
	Dataset	Static dataset or maintained dataset, Excel, Access, CSV, shapefile, etc.
	Citation	Digital copies have not been obtained
Permissions	Public	Source is readily available in public domain
	Released	Source is not published but permission has been obtained to release the information, or publication or data have been made available for distribution
	Restricted	Source is not readily available, and permission has not been obtained. Could be used to indicate the publication is protected by copyright
	TBD	Future study or ongoing study not yet completed

TOPICS AND KEY WORDS

A framework of topics and keywords was also developed to attribute sources to indicate the type of information provided by each source. The following list of topics and keywords were developed based on the topics of interest identified in the Synthesis Study and were expanded to include a higher resolution of detail within each topic based on the objectives and discussion with LPs at the December 2021 Synthesis Study Work Group meeting. These attributes are intended to be added to a relational database during screening of identified sources, with attributes being linked to references in the reference database based on a citation ID. Table A-2 provides the current list of topics and keywords being used to attribute sources during screening, with a description of each topic and keyword combination.

Table A-2. List of attributes for topics and keywords for sources.

Topic	Keyword	Notes
Geomorphology and Landforms	Change	Changes in geomorphology or processes over time
	History	Geological history and history of formation and processes
	Channel migration	Channel migration, including lateral channel migration, channel migration zones, or active channel zone
	Channel incision	Channel incision
	Sinuosity	Channel sinuosity
	Slope	Channel slope or gradient
	Floodplain	Information on floodplain width or flood prone width
	Side and off-channels	Abundance, connectivity, diversity of secondary channel habitats including braids, off-channels, and side channels
	Floodplain connectivity	Connectivity to floodplains or floodplain habitats
	Substrate and sediment	Substrate or sediment composition
	Sediment transport and supply	Sediment transport or supply, including landslides and reservoir retention
	Shallow and deep surface processes	Hydrostatic rebound, compaction, subsidence
	Large wood	Large wood abundance, recruitment, transport, retention
	Aquatic habitats and landforms	Fluvial geomorphology, or riverine landforms
	Estuarine habitats and landforms	Tidally influenced or estuarine habitats and landforms
	Climate change	Impacts of climate change on geomorphology
	Data gaps	Data gaps are identified
Water Quality and Productivity	Temperature	Temperature, maximum, mean, 7-day averages
	Nutrients	Nitrate, phosphorous, ammonia, nitrite
	Dissolved oxygen	Dissolved oxygen concentration
	pH	pH, alkalinity, acidity
	Bacteria	Fecal coliform or other bacteria
	Contaminants	Heavy metals, hydrocarbons, pesticides

Topic	Keyword	Notes
	Turbidity	Turbidity, NTU, secchi
	Salinity	Salinity and conductivity
	Primary productivity	Periphyton or algal abundance
	Secondary productivity	Invertebrate abundance or diversity
	Climate change	Impacts of climate change on water quality
	Data gaps	Data gaps are identified
Modeling Tools	Hydrology	Hydrodynamic, hydrologic, or hydraulic models
	Sediment	Sediment models
	Life cycle	Life cycle models
	Bioenergetics	Bioenergetic models or food web models
	Adult returns	Forecasting models for adult returns
	Climate change	Models the predict effects of climate change or predict climate change
	Habitat	Models describing habitat, intrinsic potential
	Connectivity	Habitat connectivity, landscape connectivity
	Data gaps	Data gaps are identified
Land Use and Cover	Land cover	General land cover information
	Forestry	Forestry and logging information, extent, management
	Agriculture	Agriculture land use information, extent
	Commercial	Commercial and industrial land use extent and types
	Urban	Urban land use information, extent
	Banks and shoreline	Levees/dikes, shoreline hardening, armoring
	Floodplain	Irrigation/diking, wetland losses/conversion
	Climate change	Climate change impacts on land cover
	Data gaps	Data gaps are identified
Fish and Habitat	Habitat, instream flow	Peak flows, flood recurrence intervals, mean flows
	Habitat, riparian	Riparian extent or condition, stand structure, buffers
	Habitat, wetlands	Wetland quantity, quality, or type
	Habitat, beaver	Beaver abundance, distribution, habitat effects, conflicts, BDAs, beaver deceiver
	Habitat, barriers	Fish passage barriers
	Habitat, invasive species	Aquatic or terrestrial invasive species
	Habitat, freshwater	Habitat quantity, quality, or type
	Habitat, estuary	Habitat quantity, quality, or type
	Habitat, pocket estuary	Habitat quantity, quality, or type
	Habitat, nearshore	Habitat quantity, quality, or type
	Habitat, ocean	Habitat quantity, quality, or type
	Habitat, connectivity	Patchiness, landscape connectivity, local connectivity, accessibility
	Habitat, capacity	Capacity of habitat to support fish

Topic	Keyword	Notes
	Habitat, limiting factors	Identifies habitat limiting factors
	Habitat, status and trends	Habitat status and trends
	Habitat, restoration	Projects, plans, designs, targets
	Habitat, climate change	Climate change impacts on habitat
	Habitat, data gaps	Data gaps are identified
	Fish, abundance	Abundance estimates for fish
	Fish, diet	Diet composition, foraging behavior, preference
	Fish, condition	Measures of condition, condition factor, lipids, weight
	Fish, density dependence	Measures of density dependent processes or patterns
	Fish, competition	Interspecific or intraspecific competition, territory
	Fish, survival	Survival at different life stages (e.g., egg to fry, smolt to adult), size selective mortality, density dependence
	Fish, growth	Growth estimates from mark recapture, otolith or scales
	Fish, swimming speed	Swimming speeds, travel speeds, movement
	Fish, physiology	Physiological studies
	Fish, rearing	Fish rearing patterns or preferences
	Fish, predation	Predation on fish, avian, marine mammal, fish
	Fish, life history	Life history characterization, description, diversity, resilience
	Fish, age structure	Age structure information
	Fish, size structure	Size structure, length frequency
	Fish, sex structure	Sex structure, ratios
	Fish, periodicity	The timing and duration of life stages
	Fish, status and trends	Population status and trends information, extent, management
	Fish, hatchery	Hatchery abundance, strategies, interactions
	Fish, harvest	Harvest rates, fisheries, exploitation rates
	Fish, climate change	Climate change impacts on fish (e.g., temperature or periodicity)
	Fish, data gaps	Data gaps are identified
	Monitoring, restoration	Monitoring restoration projects (e.g., response, effectiveness)
	Monitoring, climate change	Monitoring climate change impacts or climate change
	Monitoring, data gaps	Data gaps are identified
	Monitoring, habitat	Habitat status and trends, monitoring
	Monitoring, abundance	Smolt trap, electrofishing, seining, fyking, angling, carcass, redd, or other abundance monitoring methods
	Monitoring, biotelemetry	PIT, radio, acoustic tagging, mark recapture studies
	Monitoring, scale or otoliths	Age analysis, time of entry, residency/transition periods, growth
	Monitoring, genetics	GMR, population assignment, origin
	Monitoring, flow	Flow monitoring

DATA FLAGS

Information and data for target species, life stages, and reaches will also be identified for sources using data flags to allow for easy sorting and query of the resulting database. Flags will also be used to identify if quantitative data, spatial data, or data related to Project impacts are provided by the source. Table A-3 provides a list of data flags to support identification and classification of sources and data compiled. Note, topics and keywords are attributed with these data flags rather than the sources so that the flags can be associated with specific topics or information. For example, a source with information or data on juvenile Chinook survival from rearing to outmigration can be attributed as Topic = Fish and Habitat; Keyword = Fish, survival; Species = Chinook; Life Stage = rearing to outmigration. This approach allows specific data types to be associated to sources rather than a generic flag that could incorrectly suggest that a source contained survival information for other species or life stages. Note Reach flags may include ranges or combinations of reaches depending on the spatial extent of the study and available data. Geomorphic reach descriptions for the mainstem Skagit River were quoted from Riedel et al. (2020).

Table A-3. Data flags to support identification and classification of sources and compiled data.

Field	Values	Description
Species	Chinook	Contains information or data on Chinook Salmon
	Coho	Contains information on Coho Salmon
	Sockeye	Contains information on Sockeye Salmon
	Chum	Contains information on Chum Salmon
	Pink	Contains information on Pink Salmon
	Bull Trout	Contains information on Bull Trout
	Steelhead	Contains information on steelhead
	All	Contains information on all target anadromous species
	NA	Data not associated with target species (used for topics and keywords not related to target species)
Life Stage	Migration	Adult migration, including holding
	Spawning	Adult spawning
	Incubation	Egg incubation in substrate
	Rearing	Juvenile rearing in freshwater habitats
	Outmigration	Juvenile emigration from freshwater habitats
	Estuary rearing and emigration	Juvenile rearing, transition, and emigration through estuary habitats
	Nearshore rearing and emigration	Juvenile rearing in nearshore habitats, including pocket estuaries
	Ocean	Ocean maturation
	Migration – spawning	Adult migration through spawning
	Incubation – rearing	Incubation through rearing
	Incubation – outmigration	Incubation through outmigration
	Rearing - outmigration	Rearing through outmigration

Field	Values	Description
	Outmigration – migration	Juvenile outmigration to adult migration
	Full life cycle	Full life cycle
	NA	Does not contain information on species or life stages
Reach	US R7	Reaches upstream of R7
	Sauk River	Includes Sauk River, tributary to the mainstem Skagit River that confluences at R7
	R7	R7-Sauk River Alluvial Fan – "Wide alluvial fan that forces Skagit to north side of valley. Influenced by Glacier Peak sediment, some from lahars." RM[1] 68-65
	R8	R8-Sauk Alluvial fan to Baker Mouth – "Steep, narrowed channel because river is incised into 30-50m thick, over-consolidated glacial deposits (till, silt, sand, and gravel)." RM 65-56.5
	R9	R9-Baker to Finney Cr. – "Channel incised into glacial and lahar terraces, Baker Hydro influence on sediment, large wood, and channel pattern." RM 56.5-49
	R10	R10-Finney Cr. To Hamilton Moraine – "Sinuosity higher strong right bank ground water influence, extensive lahar terrace." RM 49-36.5
	R11	R11-HM to Sedro-Wooley – "High sinuosity in wide outwash valley wide meander loops. Extensive lahar terrace on right bank." RM 36.5-NA
	R12	R12-SW to Burlington Hill – "River leaves valley and enters Puget Lowland. Start of river levees transition to sand bed." RM NA. Downstream extent of tidally influenced habitats
	R13	R13-Delta (BH to Skagit Bay) – "Puget lowland river constrained by levees on delta, split into two distributary channels, very limited sediment and LWD." RM NA. This is the delta extent and range of tidally influenced habitats
	Skagit Bay	Skagit Bay – Skagit Bay and nearshore shoreline, including neritic and embayment habitats from the Deception Pass outlet in the North to the mouth between Whidbey Island and Camano Island in the South
	Padilla Bay	Padilla Bay – northern outlet of Swinomish Channel that is included in the geomorphic delta boundary for the Skagit River
Quantitative Data	Yes/No	Indicates whether the source provides quantitative data on the topic and keyword, and/or species and life stage
Spatial Data	Yes/No	Indicates whether the source provides spatial data on the topic and keyword, and/or species and life stage
Potential Project Impacts	Yes/No	Indicates whether the source provides information on potential Project impacts for the topic and keyword, and/or species and life stage

1 RM = river mile.

SYNTHESIS AND INTEGRATION OF INFORMATION ON RESOURCES IN THE LOWER SKAGIT RIVER INTERIM REPORT

ATTACHMENT B

ANNOTATED BIBLIOGRAPHY

This attachment will provide an annotated bibliography for relevant sources identified in the Synthesis Study. For this study report, a template for the annotated bibliography and some examples of annotated bibliographies that have been completed at the time of the ISR filing (March 2022) are provided. For each identified source, a brief summary of the source (Summary) and a narrative of how the source information supports the Synthesis Study objectives (Relevant Information) will be provided. The sources will be organized into Tier 1 Sources to highlight foundational information relevant to the Synthesis Study objectives and Tier 2 Sources that provide supporting information, as well as Other Sources that are likely to produce information that supports the Synthesis Study objectives. Within each section references will be organized alphabetically and chronologically with key information summarized for each reference including the source type; topics, species, life stages, and reaches covered; whether spatial or quantitative data are provided; and whether Project impacts are discussed in the source.

Example template for annotated bibliography

Reference	AFS Style Guide for References: https://fisheries.org/wp-content/uploads/2016/01/References.pdf. Use the "References" style in the Home tab to get the style correct for the references section.									
Source Information	***Type***	Source Type	***Status***	Draft/ Final	***Quantitative Data***	Yes/ No	***Spatial Data***	Yes/ No	***Project Impacts***	Yes/ No
Topics and Keywords	***Topic:*** keywords.									
Species and Life Stages	***Species:*** life stages.									
Reaches and Spatial extent	Reaches.									

Summary: Brief description of the study.

Relevant Information: Information specifically relevant to the Synthesis Study.

Example annotated bibliographies

Beamer et al. 2005 (Unique Identifier: 004)

Reference	Beamer, E. M., B. Hayman, and D. Smith. 2005. Linking freshwater rearing habitat to Skagit Chinook salmon recovery. Appendix C of the Skagit Chinook Recovery Plan.									
Source Information	***Type***	Report	***Status***	Final	***Quantitative Data***	Yes	***Spatial Data***	Yes	***Project Impacts***	Yes
Topics and Keywords	***Fish and Habitat:*** Habitat; status and trends, estuary, nearshore, pocket estuary, restoration, instream flow. Fish; abundance, density dependence, competition, survival, growth, rearing, predation, life history, age structure, size structure, sex structure, periodicity, status and trends, hatchery, harvest, climate change, data gaps.									
Species and Life Stages	***Chinook:*** spawning, estuary rearing and emigration, nearshore rearing and emigration, freshwater rearing and outmigration, ocean maturation.									
Reaches and Spatial extent	Mostly Reach R13 and Skagit Bay, some information on upstream reaches.									

Summary: This report is an appendix to the 2005 Skagit Chinook Recovery Plan and the authors synthesize information from over a decade of research on estuary habitat use, life history variation, estuary habitat loss, marine survival, restoration responses, and climate change impacts. One of the objectives of this report is to predict the potential benefits of restoration projects for recovering Chinook salmon in the Skagit River. The authors hypothesize that the Skagit estuary is critical to the survival of wild Chinook salmon populations in the Skagit, provide data and lines of evidence that support this hypothesis, and describe how estuary habitats are related to a diversity of Chinook abundance and demographic parameters. In addition, they present models and data that support evaluation and prioritization of restoration strategies.

Relevant Information: The information presented in this report represents a foundational reference, with extensive references and quantitative information on several topics regarding Chinook salmon relevant to the Synthesis Study objectives. The data and information presented in this report have been used to develop multiple peer-reviewed publications that were also considered in this synthesis and numerous references to relevant sources are provided. The analysis and information presented in this report are primarily focused on the Skagit River estuary (Reach R13) and nearshore (pocket estuary) habitats in Skagit Bay, but information and quantitative data are presented that link abundance and demographic patterns to upriver population abundance and demographic patterns as well as restoration strategies. The authors present several key findings that are relevant to the Synthesis Study objectives including:

- All six Chinook populations in the Skagit River express delta rearing and fry migrant life history strategies and can be found rearing in Skagit delta and pocket estuary habitats, and therefore, all six stocks utilize Skagit delta and estuary habitats for emigration as well as rearing for certain life histories.
- Freshwater rearing capacity in reaches upstream of the estuary limits the production of late migrants and excess production results in the expression of fry or early migration life histories that emigrate to estuary and nearshore habitats.

- Density dependence influences the timing of emigration, duration of rearing, size at entry, and expression of life histories and thereby use of delta, estuary, nearshore, and pocket estuary habitats.
- Delta and pocket estuary habitat extent has decreased and become more fragmented, and restoration opportunities exist for both delta and pocket estuary habitats.
- Current (circa 2005) delta habitats are limiting the abundance and size of juvenile Chinook that the delta can support through density dependent processes, and this potentially limits marine survival rates or survival at later stages based on size selective mortality.
- Restoration of pocket estuary habitat can partially mitigate the density dependence and survival impacts for fry migrants, which is influenced by freshwater water rearing capacity limitations.
- Increasing delta and pocket estuary habitat extent and connectivity should be a component of the Skagit Chinook salmon population recovery plan, and these restoration actions would address density dependent patterns and increase the abundance of juveniles produced, survival to subsequent life stages, and increase population resilience through maintenance of life history diversity.
- Climate variations influence survival, and recovery planning should consider possible shifts in marine survival related to climate change or variations in climate patterns, including planning for "worst-case scenarios" in population recovery.

The finding that freshwater rearing capacity and density dependent processes drive expression of fry and early migrant life histories suggests that management actions focused on increasing adult escapement need to be paired with actions that increase freshwater rearing capacity and estuary rearing capacity given that delta rearing capacity is currently limiting. The authors develop landscape and local connectivity models, and a quantitative model for estimating capacities and production by life history type based on adult abundance, smolt production, and estuary capacity based on both the quantity and connectivity of estuary habitats under different restoration and marine survival or climate change scenarios. These models and data are used to support development of estuarine habitat restoration strategies that include both connectivity and habitat area to support Chinook salmon recovery planning.

This report provides extensive quantitative information of juvenile life history types, size ranges, periodicity, habitat use, and mechanisms controlling or related to the expression, survival, and growth of life history types including: (1) fry migrant; (2) tidal delta rearing migrants; (3) parr migrants; and (4) yearlings. Differences in hatchery and wild juvenile Chinook densities, size, and periodicity are also presented. This information can be used to support development of conceptual life history models for Chinook salmon in the study area. Quantitative and spatial data on changes in the extent (quantity) and connectivity of delta, estuary, and pocket estuary habitats from historic (circa 1860s) to modern times (circa 1991), as well as with climate change (sea level rise) are also presented. In addition, measurements of channel density, allometric relationships, widths, edge areas, channel areas, and optimal Chinook habitat area (based on water depth and velocity) as well as distance between pocket estuary habitats are also presented in the context of juvenile Chinook abundance and life history patterns.

Connor and Pflug 2004 (Unique Identifier: 385)

Reference	Connor, E. J., and D. E. Pflug. 2004. Changes in the distribution and density of pink, chum, and Chinook salmon spawning in the upper Skagit River in response to flow management measures. North American Journal of Fisheries Management 24(3):835-852.									
Source Information	***Type***	Journal	***Status***	Final	***Quantitative Data***	Yes	***Spatial Data***	Yes	***Project Impacts***	Yes
Topics and Keywords	***Fish and Habitat:*** Habitat: instream flow. Fish: periodicity, age structure, abundance. Monitoring: abundance.									
Species and Life Stages	***Pink***: spawning, incubation, emergence, rearing, outmigration. ***Chum***: spawning, incubation, emergence, rearing, outmigration. ***Chinook***: spawning, incubation, emergence, rearing, outmigration.									
Reaches and Spatial extent	R8 – R7 and reaches upstream of the study area for the Synthesis Study.									

Summary: This study analyzed time series of the spatial distribution and abundance of Pink, Chum, and Chinook spawning in a 27-mile reach of the upper Skagit River with respect to implementation of flow management measures in 1981. Their study area was divided into three reaches: (1) Reach 1 from George Powerhouse downstream to Marblemount; (2) Reach 2 from Marblemount to Rockport and Sauk River confluence; and (3) Reach 3 downstream of Sauk River confluence to Baker River confluence. These flow management measures were intended to minimize redd dewatering during spawning and incubation periods and reduce fry stranding during emergence and outmigration life stages. Their study included analysis of changes in flows and spawner data during per-agreement (1950-1980), interim agreement (1981-1990), and final agreement periods (1991-2001), including comparing trends in spawner abundance with other nearby systems to support interpretation of patterns and their relationship to flow management measures. Their study design was a before-after impact comparison and they concluded that increasing minimum flows during incubation periods improved redd protection levels, and that fry stranding was reduced by reducing the number of downramping events and timing of downramping events during the daytime when fry are more vulnerable to stranding. They also found that spawner abundances increased with the flow measures, and that increases were strongest in the upstream most reaches closest to the Project.

Relevant Information: The report provides quantitative data that are relevant to the Synthesis Study and specifically on Project impacts. The study focused on reaches upstream of the Baker River confluence, and therefore is directly relevant to Reaches 7-8 in the study area for the Synthesis Study, but their analysis included Project impacts in reaches upstream of Reach 7. Their study area included a Reach 3 that includes all of the Synthesis Study area Reach 8 and the downstream portion of Reach 7, and a Reach 2 that includes the upstream portion of Reach 7 at the Sauk River confluence. Therefore, results summarized in this report are relevant to Reaches 7 and 8 in the study area for the Synthesis Study.

Flow metrics related to Project impacts and salmon life stages are provided including: spawning flows, minimum flow releases, downramping amplitude limits, maximum downramp rate for pre-agreement, interim agreement, and final agreement periods; monthly max, mean, and minimum flows are provided for pre-(1909-1930) and post-Project periods (1981-2001); frequency plots (5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles) of minimum discharge during the incubation period for Chinook, Chum, and Pink salmon pre-agreement, interim agreement, and final agreement

periods; change in discharge during Chinook, Pink, and Chum spawning periods for pre, interim, and final agreement flows; and annual downramping metrics for pre, interim, and final agreement periods (number of downramping events, daytime downramping percent, average downramp amplitude, and average downramp rate).

Fish metrics related to Project impacts include: average density of chum and pink spawners and Chinook redds by reach for pre (<1985) and post (>1985) periods; trends in escapement for odd-year pink, fall-run chum, and summer-fall run Chinook for upper and lower Skagit River (percent per year, mean, S.E.) for 1959-1981 and 1983-2001.

Significant Project impacts were detected mostly in reaches upstream of the study area for the Synthesis Study with effects attenuating with distance downstream of the Project (which the authors attribute partly to the influence of unregulated tributaries entering the Skagit River with increasing distance downstream) and included; significant increase in pink salmon spawner abundance in Reach 7 and in upstream reaches; significant increases in chum spawner abundance in reaches upstream of the study area but not in Synthesis Study reaches; significant increases in Chinook redds in Reach 7 and reaches upstream of the study area for the Synthesis Study; significant increasing trends in Pink and Chum post agreement that were greater than trends observed in other basins; and stable abundance of Chinook salmon in the study area for the Synthesis Study compared to declining trends in unregulated basins of the Skagit River. The authors link the observed changes in fish abundance metrics with distance from the Project to changes in egg-to-fry survival that are inferred from improved redd survival and stranding with implementation of the flow agreement, but these are interpretations of the data and not supported by monitoring data during these life stages.

Riedel et al. 2020 (Unique Identifier: 001)

Reference	Riedel, J., S. Sarrantonio, K. Ladig, and M. Larrabee, 2020. DRAFT Skagit River geomorphology inventory report: part I – Gorge Dam to Sauk River. Report prepared by the National Park Service for Seattle City Light, Seattle, Washington.									
Source Information	***Type***	Report	***Status***	Draft	***Quantitative Data***	Yes	***Spatial Data***	Yes	***Project Impacts***	Yes
Topics and Keywords	***Geomorphology:*** change, history, channel migration, channel incision, sinuosity, floodplain, secondary channels, floodplain connectivity, substrate and sediment, sediment transport and supply, aquatic habitats and landforms, estuarine habitats and landforms. ***Fish and Habitat:*** instream flow.									
Species and Life Stages	None.									
Reaches and Spatial extent	Reaches R7-R13, plus upstream reaches R1-R6.									

Summary: This is a draft study report that was prepared for City Light to address one of eight identified data gaps related to the physical state of aquatic and riparian habitats in the Skagit Valley—mapping of surficial geology. The authors anticipate that the information developed in this study will inform management of cultural resources, habitat restoration, and future studies. A total of 13 geomorphic reaches were delineated and described in this study, with information on dominant habitat forming processes and history, as well as current landforms and processes, from

Skagit Gorge to the Skagit Delta/Estuary. As part of this study, over 800 distinct landforms were identified and digitized in a Geographic Information System (GIS) for the upper Skagit Valley, but detailed descriptions of reaches were only provided for the upper reaches (R1-R6 upstream of the Sauk River confluence) in this draft. The authors indicate that more detailed mapping of the lower reaches (R7-R13) will be developed in the next phase of the study.

Relevant Information: This report defines the geomorphic reaches that will be used in the Synthesis Study and the dominate processes that formed and control geomorphic features and processes in these reaches. Reaches relevant to the study area for the Synthesis Study are defined as R7 (Sauk River Alluvial Fan – "Wide alluvial fan that forces Skagit to north side of valley. Influenced by Glacier Peak sediment, some from lahars." RM 68-65), R8 (Sauk Alluvial Fan to Baker Mouth – "Steep, narrowed channel because river is incised into 30-50m thick, over-consolidated glacial deposits (till, silt, sand, and gravel)." RM 65-56.5), R9 (Baker to Finney Cr. – "Channel incised into glacial and lahar terraces, Baker Hydro influence on sediment, large wood, and channel pattern." RM 56.5-49), R10 (Finney Cr. To Hamilton Moraine – "Sinuosity higher strong right bank ground water influence, extensive lahar terrace." RM 49-36.5), R11 (HM to Sedro-Wooley – "High sinuosity in wide outwash valley wide meander loops. Extensive lahar terrace on right bank."), R12 (SW to Burlington Hill – "River leaves valley and enters Puget Lowland. Start of river levees transition to sand bed."), and R13 (Delta (BH to Skagit Bay) – "Puget Lowland river constrained by levees on delta, split into two distributary channels, very limited sediment and LWD.").

However, detailed mapping of landforms in these reaches were not developed in this phase of the study but future efforts will develop spatial data for landforms (e.g., terraces, alluvial fans, mass-wasting deposits, gravel bars, islands, and active and relict side channels) as well as edge maps, relative elevation models, geologic cross sections, contours, and shading; and quantitative data were collected or developed describing valley and channel characteristics (e.g., valley width, sinuosity, and depth to groundwater) that will support Synthesis Study objectives. The authors also briefly discuss potential Project impacts of flow regulation and reservoirs on downstream habitats and habitat forming processes through reduced peak flow events and a 70 percent reduction in sediment supply, However, limited quantitative data are presented in this report although it is possible that more information on Project impacts will be developed in Part 2 of the study focused on the lower reaches (R7-R13).

Greene et al. 2005 (Unique Identifier: 050)

Reference	Greene, C. M., D. W. Jensen, G. R. Pess, E. A. Steel, and E. Beamer. 2005. Effects of environmental conditions during stream, estuary, and ocean residency on Chinook salmon return rates in the Skagit River, Washington. Transactions of the American Fisheries Society 134:1562-1581.									
Source Information	***Type***	Journal	***Status***	Final	***Quantitative Data***	Yes	***Spatial Data***	No	***Project Impacts***	No
Topics and Keywords	***Fish and Habitat:*** Habitat: limiting factors, freshwater, estuary, nearshore, ocean; Fish: periodicity, harvest, hatchery, age structure, survival, sex structure, abundance, density dependence, competition, data gaps. ***Monitoring***: abundance. ***Models***: adult returns.									
Species and Life Stages	***Chinook:*** Full life cycle, incubation to outmigration, estuary rearing to emigration, nearshore rearing to emigration, ocean, migration, spawning.									
Reaches and Spatial extent	Skagit Bay and R7-R13 plus upstream reaches.									

Summary: The authors used a 22-year time series of wild Chinook returns to the Skagit River to build predictive models based on environmental conditions experienced during freshwater, tidal delta, bay, and ocean life stages (1974-1995 brood years). They found that the best predictors of adult return rates were the magnitude of floods during incubation, as described by flood recurrence interval (FRI), and principal components of multiple indices of environmental conditions during bay residency and the third ocean year. The models they developed explained 90 percent of the variance in return rates with high forecasting precision, but ocean conditions only explained 5 percent of the variance, suggesting that conditions experienced during freshwater and delta life stages are more predictive of adult return rates than ocean conditions. They also found evidence of density dependence during incubation as indicated by the inclusion of an egg abundance parameter in the predictive model, but they found no evidence for competition effects from Pink salmon abundance.

Relevant Information: This source provides quantitative data on fish and habitat, and models that can be used to inform the Synthesis Study. They developed a conceptual model for conditions experienced during different life stages and how they influence survival at different stages, including factors like FRI, sea surface temperatures (SST), sea level pressure (SLP), coastal upwelling index (UWI), and sea level (SL). Data used in this analysis are readily available and frequently updated/maintained and would support future analyses or expansion of analysis. The data and models provided in this source can be used to inform conceptual life cycle models and quantitative life cycle models as well as evaluate limiting factors and adult return forecasting. Quantitative information on the periodicity of Chinook in the Skagit System is provided as well as estimates of escapement to river, egg deposition, age-specific fecundity, age structure, sex structure, hatchery interactions, mixed stock harvest, terminal harvest, spawners per spawner and recruits per spawner for each brood year. The authors also discuss data limitations with respect to escapement estimates and harvest rates and how these impact the model results, including identification of important variables, and general monitoring of factors that inform management actions or monitoring needs for future research.

SYNTHESIS AND INTEGRATION OF INFORMATION ON RESOURCES IN THE LOWER SKAGIT RIVER INTERIM REPORT

ATTACHMENT C

LIST OF REFERENCES

This attachment provides a preliminary list of sources compiled and identified as part of Task S1 for the Synthesis Study for review as of December 30, 2021. Sources listed in the ***Compiled References*** section are sources that have information potentially relevant to this Synthesis Study and digital copies have been archived for screening and review. Note: these include online or web sources from which relevant information can be extracted and archived. Sources identified as ***References Needed*** are sources that have been identified but digital copies have not yet been secured to support screening and review. This list is being provided to LPs to facilitate identification of potential sources that have not yet identified or compiled, and to support archiving of digital copies for references have not yet been secured.

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SYNTHESIS AND INTEGRATION OF INFORMATION ON RESOURCES IN THE LOWER SKAGIT RIVER INTERIM REPORT

ATTACHMENT D

OTHER SOURCES

The section will provide a list of sources that were identified and screened but were determined to not provide information relevant to the geographic extent of the study area for the Synthesis Study. These references will be provided to support future studies and are organized by sources that provide information not directly related to the Skagit River basin (Out of System) and those that provide information for the Skagit Basin but are not specific to the study area for the Synthesis Study (Out of Study Area).

OUT OF SYSTEM

AFS styled reference list.

OUT OF STUDY AREA

AFS styled reference list.