APPENDIX N

ESSENTIAL FISH HABITAT ASSESSMENT

JUNEAU ACCESS IMPROVEMENTS
SUPPLEMENTAL DRAFT
ENVIRONMENTAL IMPACT STATEMENT

STATE PROJECT NUMBER: 71100
FEDERAL PROJECT NUMBER: STP-000S (131)

Prepared for

Alaska Department of Transportation and Public Facilities
6860 Glacier Highway
Juneau, Alaska 99801-7999

Prepared by

URS Corporation
8411 Airport Blvd.
Juneau, Alaska 99801

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLES

TABLE OF CONTENTS (continued)

FIGURES

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
Act	Magnuson-Stevens Fishery Conservation and Management Act
ADEC	Alaska Department Environmental Conservation
ADF&G	Alaska Department of Fish and Game
AADT	Annual Average Daily Traffic
ADT	Average daily traffic
ASA	Age structured analysis
AMHS	Alaska Marine Highway System
AWQS	Alaska Water Quality Standards
Catalog	Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes
CFEC	Commercial Fisheries Entry Commission
CFR	Code of Federal Regulations
DOT&PF	Alaska Department of Transportation and Public Facilities
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
EIS	Environmental Impact Statement
EIT	East Intertidal Station
ESCP	Erosion and Sedimentation Control Plan
FC	fecal coliform
FHWA	Federal Highway Administration
FVF	fast vehicle ferry
GPS	Global Positioning System
HAPC	Habitat Areas of Particular Concern
ITZ	Intertidal Zone
M.V.	marine vessel
MLLW	mean lower low water
MOA	memorandum of agreement
NEPA	National Environmental Protection Act
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPFMC	North Pacific Fisheries Management Council
NWI	National Wetlands Inventory
OHMP	Office of Habitat Management and Permitting
PAH	Polycyclic Aromatic Hydrocarbons
SAW	Sawmill Cove
SDEIS	supplemental draft environmental impact statement
SIMS	Seabed Imaging and Mapping System
SLA-1	Slate Cove
STN	station
TPH	Total Petroleum Hydrocarbons
TSS	total suspended solids
U.S.	United States
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
UV	ultraviolet
WHB	William Henry Bay

EXECUTIVE SUMMARY

This report describes the marine, estuarine, and anadromous habitats and species in Lynn Canal that may be affected by the Juneau Access Improvements alternatives. As required by the Magnuson-Stevens Conservation and Management Act, this report also assesses the essential fish habitat (EFH) in the area, which is defined as “waters and substrate necessary for fish for spawning, breeding, feeding, or growth to maturity.” A consultation with National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) produced a list of fish species for the focus of the EFH analysis whose lives could be adversely affected by the proposed project alternatives. This report provides a summary of each EFH species’ life history and, as applicable to the species or its habitat, provides an analysis of effects of the proposed actions (direct, indirect, and cumulative). A separate report, the *Anadromous and Resident Fish Streams Technical Report,* (Appendix P to the Supplemental Draft Environmental Impact Statement [SDEIS]) describes the freshwater streams within the project area used by the anadromous and resident fish species, and the potential effects of project bridge construction and operations in the streams on these species.

The results of subtidal and intertidal surveys that were conducted in 2003 at potential ferry terminal construction sites, potential highway fill sites, and sites representative of areas that may be impacted by sidecasting (due to highway construction) are presented in this report. The intertidal surveys were conducted at sites within the intertidal zone, which includes the area on the shore between the extremes of high and low tide (49 sites). The subtidal surveys occurred at sites located seaward of the lowest tide zone to depths averaging 120 feet (31 sites). Each of these surveys provided information about observations of animals (i.e., fish, mollusks), vegetation (i.e., algae, kelp), and substrate (i.e., boulders, mud) within each respective area. Information regarding anadromous stream habitat that may be affected by highway bridge construction was gleaned from the *Anadromous and Resident Fish Streams Technical Report.* This information, along with historical information, provided a foundation for the assessment of the affected environment within the project area. This assessment, in turn, served as the basis for the analysis of the effects of the project alternatives on marine, estuarine, and anadromous habitat, and marine fish species. This report details the analysis of direct, indirect, and cumulative effects of the proposed project on this EFH and species. An analysis of the indirect and cumulative effects of the project alternatives on EFH as well as anadromous and resident fish streams is also presented in the *Indirect and Cumulative Effects Technical Report*.

Certain locations potentially impacted by the project alternatives have been identified as supporting various life stages of EFH species, including William Henry Bay, Sawmill Cove, Slate Cove, and a site north of the Katzehin River. The construction of Alternatives 2 through 2C would result in the direct loss of 21.9 (Alternative 2C) to 35 (Alternative 2A) acres of essential fish habitat as a result of filling for highway and ferry terminal filling and dredging, as well as the modification of subtidal habitat resulting from sidecasting shot rock. Alternative 3 would result in the direct loss of 12.9 acres of essential fish habitat as a result of filling for highway and ferry terminal filling and dredging. Alternatives 4B and 4D would result in the loss of 3.2 acres of essential fish habitat for the dredging and filling at the Sawmill Cove ferry terminal. With Alternatives 2A, 3, 4B, and 4D, the 3.2 acres of habitat lost at Sawmill Cove is historically documented spawning habitat for Lynn Canal Pacific herring stock. Ferry maneuvers at Sawmill Cove could increase turbidity in the vicinity of the terminal sufficiently to impact Pacific herring eggs and larvae at the terminal site.

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1.0 INTRODUCTION

This document has been prepared to fulfill a dual purpose:

- To satisfy the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (Act) (see Section 1.1 for a definition of the Act).
- To serve as the Technical Report for the marine, estuarine, and anadromous environments of Lynn Canal that could be impacted by Juneau Access Improvements Project alternatives, including presentation of the results of intertidal and subtidal field studies.

This *Essential Fish Habitat Assessment* report describes life history information for the marine and anadromous species that are known to occur in the project area, their habitats, and potential impacts to these habitats and species.

1.1 Definition of EFH and Regulatory Requirements

On October 11, 1996, Congress passed the Sustainable Fisheries Act (Public Law 104-297), which amended the habitat provisions of the Act. This 1996 reauthorization of the Act mandates that Federal agencies assess the effects of Federal projects on essential fish habitat (EFH) for commercial fish stocks in all life stages and habitats. This Act also calls for direct action to stop or reverse the continued loss of fish habitats. The Act requires consultation between the National Oceanic Atmospheric Administration National Marine Fisheries Service (NMFS), the Fishery Management Councils, and federal agencies to protect, conserve, and enhance EFH. The Act defines EFH as “waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” The Act considers *fish* to include finfish, mollusks, crustaceans, and other forms of marine life excepting marine mammals and birds. The Act defines *waters* as “aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish, where appropriate”; *substrate* as “sediment, hard bottom, structures underlying the waters, and associated biological communities”; and *necessary* as “the habitat required to support a sustainable fishery and a healthy ecosystem.” In considering an *adverse effect* to EFH, Subpart J, Section 600.810 of the Act defines an adverse effect to EFH as “any impact, which reduces the quality and/or quantity of EFH.”

1.2 EFH Consultation Process

Through the consultation process, NMFS may recommend ways to avoid or minimize the effects of the proposed action on EFH. Consultation is initiated when a Federal agency notifies NMFS of an action that may adversely affect EFH and provides NMFS with an EFH Assessment. In response to the EFH Assessment, NMFS provides the Federal agency with conservation recommendations to avoid, minimize, mitigate, or otherwise offset adverse effects on EFH. In the case of this project, consultation will be initiated with the submittal of the final EFH Assessment and public review supplemental draft environmental impact statement (SDEIS) to NMFS.

An agreement between NMFS, Federal Highway Administration (FHWA), and Alaska Department of Transportation and Public Facilities (DOT&PF) details how EFH Assessments will be implemented for FHWA projects in Alaska. The following points of the agreement apply to the EFH Assessment and Consultation at this stage of the Juneau Access Improvements Project:

1. DOT&PF, in accordance with 50 Code of Federal Regulations (CFR) 600.920(c) will be the designated representative of the FHWA in the EFH consultation process. However, the FHWA remains ultimately responsible for compliance.
2. An EFH assessment will be incorporated in a National Environmental Policy Act (NEPA) document and will be titled or co-titled as such.
3. DOT&PF will provide NMFS the preliminary SDEIS, including the draft EFH Assessment for their review and comment. NMFS will respond as appropriate, including preliminary EFH conservation recommendations. If NMFS believes that the proposed action may result in substantial adverse effects on EFH, or that additional analysis is needed to accurately assess the effects of the proposed action, NMFS will request that FHWA initiate expanded consultation.
4. DOT&PF will revise or amend the EFH Assessment and/or the project as appropriate based on comments and necessary additional coordination with NMFS.
5. Transmittal of the final EFH Assessment with the public review SDEIS to NMFS will be considered "Submittal of the EFH Assessment" under 50 CFR 600.920(h)(3).

Based on preliminary consultation with NMFS, DOT&PF has determined that the alternatives may adversely affect the following fish species and specific life stages. DOT&PF will coordinate further with NMFS by submitting this EFH Assessment to officially initiate consultation at the time the SDEIS is released for public review.

- Pacific salmon: pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), sockeye (*O. nerka*), coho (*O. kisutch*), and Chinook (*O. tshawytscha*) – eggs, fry, smolt, and spawning adults.
- Sablefish *(Anoploma fimbria)* – juveniles and occasionally adults.
- Yelloweye rockfish *(Sebastes ruberrimus)* and other rockfish (*Sebastes)* species – adults; other life stages are unknown.
- Sculpin *(*Family *Cottidae)* – eggs, juvenile, and adults.
- Skate *(*Family *Rajiidae)* – adults; other life stages unknown.
- Forage fish (Pacific herring [*Clupea pallasii*]*,* eulachon [*Thaleichthys pacificus*], capelin [*Mallotus villosus*]*,* and sand lance [*Ammodytes hexapterus*]) – eggs, juveniles, and adults. Note: Although Pacific herring is not a NMFS-managed species in the Gulf of Alaska Fishery Management Plan, they are included in this analysis based on their importance as a forage fish.

In addition to these fish species, the Office of Habitat Management and Permitting (OHMP) has, in conjunction with ADF&G, suggested that several species of crab be included in the EFH Assessment. Although no Federal fishery management plan exists for the commercial king or Dungeness crab fisheries in the Gulf of Alaska, OHMP recommends that red king crab (*Paralithodes camtschaticus*), blue king crab (*P. platypus*), and Dungeness crab (*Cancer magister*) be included in the analysis because of their intertidal habitat requirements and human use values. We are also including bairdi tanner crab (*Chionoecetes bairdi*) because they are commercially fished in Lynn Canal and are found in habitat similar to king and Dungeness crabs.

As a result of statutory changes in 2003, ANDR OHMP is responsible for specifying rivers, lakes, and streams or parts of them that are important for spawning, rearing, or migration of anadromous fishes under Alaska Statute 41.14.870(a). ADF&G continues to be involved in anadromous water body nominations.

Section 4.3 provides detailed descriptions and life histories of the marine and anadromous fish and crab listed above. As summarized below, the section also discusses the potential for occurrence in Lynn Canal for these species:

- Pacific Salmon species – EFH includes all stream, estuarine, and marine areas used by all five species of Pacific salmon, regardless of the geography of their natal origin, extending from the headwaters of natal streams to the limits of the United States (U.S.) Exclusive Economic Zone (EEZ, 200 miles offshore). Identified anadromous fish streams in the project area and details on the use of these streams by anadromous and resident species are provided in the *Anadromous and Resident Fish Streams Technical Report* (Appendix P of the SDEIS). Lynn Canal provides an essential migratory corridor for all five species of Pacific salmon.
- Sablefish, a marine fish species, are known to rear in estuarine waters in Lynn Canal and have been observed in Berners Bay and Echo Cove.
- Rockfish – There is limited information regarding the use of Lynn Canal by these fish; however, they have been documented near Vanderbilt Reef, approximately 4 miles southwest of the project area, and near Point Lena and Point Therese, approximately 20 and 30 miles south of the project area, respectively, at depths between 40 and 90 feet.
- Sculpins are common at intertidal and subtidal sites throughout Lynn Canal.
- Skates were abundant in Lynn Canal in the 1970s and are occasionally caught in Berners Bay.
- Forage fish (prey species), such as eulachon and herring, are abundant in Berners Bay and are supported by estuarine wetlands. Eulachon are known to spawn in the Lace, Berners and Antler rivers, and are therefore considered to be anadromous. Although capelin are known to spawn in Berners Bay, knowledge of spawning activities in other parts of Lynn Canal is limited. In the past, Pacific herring was commercially harvested in upper Lynn Canal; the harvest was terminated when abundance dropped below sustainable levels. Herring are known to spawn on kelp, eelgrass, and other substrate in and around Berners Bay, from Cascade Point to Berners Bay mudflats, and on the west side of the Chilkoot Inlet. EFH for forage fish includes all estuarine and marine areas extending from the influence of tidewater and tidally submerged habitats to the limits of the EEZ. EFH for eulachon also includes headwaters of spawning rivers. A separate report, *Reconnaissance Evaluation of Ecological Effects to Forage Fish Populations Associated With the Juneau Access Improvements Project* (see Attachment C of this document) provides detailed information on forage fish species.
- The species of crabs listed above are generally found at depths between the intertidal zone and 600 feet, depending on their life stage. Commercial and personal use fisheries for these crabs exist throughout Lynn Canal.

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2.0 PROJECT DESCRIPTION

2.1 Project Purpose and Need

The purpose of and need for the Juneau Access Improvements Project is to provide improved surface transportation to and from Juneau within the Lynn Canal corridor that will:

- Provide the capacity to meet the transportation demand in the corridor
- Provide flexibility and improve opportunity for travel
- Reduce travel time between Lynn Canal communities
- Reduce state costs for transportation in the corridor
- Reduce user costs for transportation in the corridor

2.2 Project Description

Lynn Canal, located approximately 25 miles north of Juneau, is the waterway that connects Juneau with the cities of Haines and Skagway via the Alaska Marine Highway System (AMHS). At present there is no roadway connecting these three cities. The Glacier Highway originates in Juneau and ends at Echo Cove, approximately 40.5 miles to the northwest.

As required by the National Environmental Policy Act (NEPA), the Supplemental Draft Environmental Impact Statement (SDEIS) for the Juneau Access Improvements Project considers the following reasonable alternatives:

Alternative 1 – No Action Alternative – The No Action Alternative includes a continuation of mainline AMHS service in Lynn Canal as well as the operation of the fast vehicle ferry (FVF) *M/V Fairweather* between Auke Bay and Haines and Auke Bay and Skagway. The *M/V Aurora* would provide shuttle service between Haines and Skagway, beginning as early as 2005.

Alternative 2 (Preferred) – East Lynn Canal Highway with Katzehin Ferry Terminal – This alternative would construct a 68.5-mile-long highway from the end of Glacier Highway at the Echo Cove boat launch area around Berners Bay to Skagway. A ferry terminal would be constructed north of the Katzehin River delta, and operation of the *M/V Aurora* would change to shuttle service between Katzehin and the Lutak Ferry Terminal in Haines. Mainline ferry service would end at Auke Bay, and the existing Haines/Skagway shuttle service would be discontinued. The *M/V Fairweather* would be redeployed on other AMHS routes.

Alternative 2A – East Lynn Canal Highway with Berners Bay Shuttles – This alternative would construct a 5.2-mile highway from the end of Glacier Highway at Echo Cove to Sawmill Cove in Berners Bay. Ferry terminals would be constructed at both Sawmill Cove and Slate Cove, and shuttle ferries would operate between the two terminals. A 52.9-mile highway would be constructed between Slate Cove and Skagway. A ferry terminal would be constructed north of the Katzehin River delta, and the *M/V Aurora* would operate between the Katzehin and the Lutak Ferry Terminals. Mainline ferry service would end at Auke Bay, and the existing Haines/Skagway shuttle service would be discontinued. The *M/V Fairweather* would be redeployed on other AMHS routes.

Alternative 2B – East Lynn Canal Highway to Katzehin with Shuttles to Haines and Skagway – This alternative would construct a 50.5-mile highway from the end of Glacier Highway at Echo Cove around Berners Bay to Katzehin, construct a ferry terminal at the end of the new highway, and run shuttle ferries to both Skagway and Haines from the Katzehin Ferry Terminal. The Haines to Skagway shuttle service would continue to operate, two new shuttle ferries would be constructed, and the *M/V Aurora* would be part of the three-vessel system. Mainline AMHS service would end at Auke Bay. The *M/V Fairweather* would be redeployed on other AMHS routes.

Alternative 2C – East Lynn Canal Highway with Haines/Skagway Shuttle – This alternative would construct a 68.5-mile highway from the end of Glacier Highway at Echo Cove around Berners Bay to Skagway with the same design features as Alternative 2. The *M/V Aurora* would continue to provide service to Haines. No ferry terminal would be constructed at Katzehin. Mainline ferry service would end at Auke Bay, and the *M/V Fairweather* would be redeployed on other AMHS routes.

Alternative 3 – West Lynn Canal Highway – This alternative would extend the Glacier Highway 5.2 miles from Echo Cove to Sawmill Cove in Berners Bay. Ferry terminals would be constructed at Sawmill Cove and William Henry Bay on the west shore of Lynn Canal, and shuttle ferries would operate between the two terminals. A 38.9-mile highway would be constructed between William Henry Bay and Haines with a bridge across the Chilkat River/Inlet connecting to Mud Bay Road. The *M/V Aurora* would continue to operate as a shuttle between Haines and Skagway. Mainline ferry service would end at Auke Bay, and the *M/V Fairweather* would be redeployed on other AMHS routes.

Alternatives 4A through 4D – Marine Options – The four marine alternatives would construct new shuttle ferries to operate in addition to continued mainline service in Lynn Canal. All of the alternatives would include a minimum of two mainline vessel round trips per week, year-round, and continuation of the Haines/Skagway shuttle service provided by the *M/V Aurora*. The *M/V Fairweather* would no longer operate in Lynn Canal. All of these alternatives would require construction of a new double stern berth at Auke Bay.

Alternative 4A – FVF Shuttle Service from Auke Bay – This alternative would construct two FVFs to provide daily summer service from Auke Bay to Haines/Skagway.

Alternative 4B – FVF Shuttle Service from Berners Bay – This alternative would extend the Glacier Highway 5.2 miles from Echo Cove to Sawmill Cove in Berners Bay, where a new ferry terminal would be constructed. Two FVFs would be constructed to provide daily service from Sawmill Cove to Haines/Skagway in the summer and from Auke Bay to Haines/Skagway in the winter.

Alternative 4C – Conventional Monohull Shuttle Service from Auke Bay – This alternative would construct two conventional monohull vessels to provide daily summer service from Auke Bay to Haines/Skagway. In winter, shuttle service to Haines and Skagway would be provided on alternate days.

Alternative 4D – Conventional Monohull Shuttle Service from Berners Bay – This alternative would extend the Glacier Highway 5.2 miles from Echo Cove to Sawmill Cove in Berners Bay, where a ferry terminal would be constructed. Two conventional monohull vessels would be constructed to provide daily service from Sawmill Cove to Haines/Skagway in the summer and alternating day service from Auke Bay to Haines/Skagway in the winter.

Alternatives that have the highest potential to impact EFH are those that include new construction of a highway and/or ferry terminals:

- Alternative 2 – new highway construction; one new ferry terminal
- Alternative 2A – new highway construction; three new ferry terminals
- Alternative 2B – new highway construction; one new ferry terminal
- Alternative 2C – new highway construction only; no new ferry terminals
- Alternative 3 – new highway construction; two new ferry terminals
- Alternative 4B and 4D – new highway construction; one new ferry terminal

Under these alternatives, construction of ferry terminals, bridges, and embankment fills; sidecasting of materials during highway construction activities; and ferry operations could potentially have short- and long-term effects on intertidal and subtidal fish habitat.

Alternatives 4A and 4C do not require additional highway construction or new ferry terminals but do change the structure and frequency of ferry service in Lynn Canal. These changes, along with continued service under the No Action Alternative, could cause impacts to fish habitat due to disturbance from ferry vessel operations or the potential effects of permitted or accidental discharges.

While there are no new highways under Alternatives 4A and 4C, modification of the existing ferry terminal at Auke Bay would occur under all Alternative 4 options (4A through 4D). A new double stern berth would accommodate the needs of the Juneau Access Improvements Project under Alternatives 4A through 4D because two vessels would be utilized for north Lynn Canal service under these alternatives.

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3.0 FIELD STUDIES AND METHODOLOGY

Thirty-one subtidal and 49 intertidal sites were identified within the project area where marine habitat could potentially be affected by highway or ferry terminal construction and operations. In order to characterize the habitat at these sites, subtidal and intertidal surveys were conducted during August 2003. The results of these field surveys and a description of the affected environment are presented in this section. Photographs from the field survey and field location maps are presented in Attachments A and B. In addition, the project alternatives could impact EFH at anadromous and resident fish streams within the alternative highway alignments. These streams that have been identified in the project area are discussed in detail in the *Anadromous and Resident Fish Streams Technical Report*.

3.1 Subtidal Mapping of Selected Sites Along Lynn Canal

3.1.1 Background

Thirty-one subtidal areas within the Lynn Canal project area were surveyed using the Seabed Imaging and Mapping System (SIMS), which consists of a video camera that is towed just above the seabed and a video recording system that links Global Positioning System (GPS) fixed locations to the imagery. These sites were potential locations of highway fill, ferry terminal fill or dredge, or areas were excess rock would be sidecast. Figure 3-1 and the figures in Attachment B provide the subtidal survey location maps; Table 3-1 provides a field tape log summary of the survey locations. GPS positions and the tide-corrected depths of the towfish are burned onto each frame of the video imagery, so that the location of each frame is recorded. The image size varies depending on the height of the towfish; if the towfish is flown close to the seabed due to restricted visibility, then the image will be smaller, typically 1.6 feet square. If visibility is good, then the towfish may be flown several yards above the seabed and the area of image will be increased to several square yards. Two lasers are aligned with the camera and are a fixed distance of 7.9 inches apart; these show on the image as two dots on the seabed and provide classifiers with a fixed scale.

Databases for geological classification and biological classification data include a classification record for each two seconds of imagery. A geologist classifies the geological and anthropological artifacts on the seabed while a biologist classifies the biota. Although the scientists classify all that they observe the only records entered into the database are those where there are changes in the seabed features. Therefore, if the bottom is uniform in terms of sediments or biota, no records will be entered until the sediment or biota changes. For example, when classifying an eelgrass (*Zostera marina*) bed, the biologist may be classifying the cover as 5 to 25 percent and no new records will be entered until a different cover class of eelgrass occurs (e.g., trace to 5 percent or 25 to 75 percent).

The completed databases include geological and biological attributes, along with their geographic positions. Plots of the attributes (or combinations thereof) provide a picture of the spatial distributions of selected features at each site (e.g., eelgrass occurrence).

3.1.2 Survey Data

The Lynn Canal SIMS survey was conducted between August 18 and 21, 2003. Thirty-one sites were surveyed (see Table 3-1, Figure 3-1 and Attachment B), and 21 digital videos containing about 19.5 hours of imagery were recorded (Table 3-1). Individual tracklines for each site were plotted on National Oceanic and Atmospheric Administration nautical charts. The SIMS system was installed on the *M/V Stikine*, a 32-foot aluminum gill-netter. The vessel was an excellent support system because (a) it was possible to use a slow towing speed, (b) a bow thruster allowed easy positioning and line tracking, and (c) the vessel's shallow draft allowed surveys to be conducted into intertidal zones.

3.1.3 Classification Procedure

Examples of the SIMS classification procedure used for this survey are provided at the following website: http://www.veheap.crd.bc.ca/select.htm. Classification attributes are summarized for geological features (Table 3-2) and biological features (Tables 3-3 through 3-6).

3.2 Intertidal Surveys

Surveys of 49 intertidal sites were conducted during low tide over the period August 26 to 29, 2003 (see Figure 3-1 and Attachment B). Forty-one of these sites were identified by DOT&PF as possible fill locations for highway construction. Four sites were investigated as representative of typical locations where, due to the steep terrain, rock from blasting would fall uncontrolled directly through the intertidal zone (uncontrolled sidecasting), or would be used as intentionally controlled sidecasting locations. The remaining four sites are situated at potential ferry terminal locations: Sawmill Cove (SAW), William Henry Bay (WHB; the only site visited on the west side of Lynn Canal), Slate Cove (SLA-1), and Katzehin Ferry Terminal (east intertidal station [EIT] 11).

Table 3-7 documents the sites visited, time, date, and approximate tidal height during the visit, and beach conditions such as geomorphology, wave exposure, and observed organisms. The table also indicates the survey method, which was either on foot or from the boat, or both. The surveys were timed such that nearly all of the intertidal sites were visited at a tidal height of less than approximately 2.5 feet above mean lower low water (MLLW) (see Table 3-7). However, the river channel, upland, and tidal slough sites (EIT 12, and EIT 42 through 46) were visited at higher tidal elevations due to time and access constraints.

A team consisting of two biologists and a boat operator/assistant conducted the field survey. Where topography and wave conditions allowed access, both biologists walked the beach, recording qualitative data on organisms present and their relative abundance. This type of survey was conducted at 25 of the sites (see Table 3-7). Level of effort for foot surveys remained relatively constant among sites surveyed in this manner. The remaining sites were surveyed by boat. The boat surveys were conducted by pulling the boat very close to the shoreline; this was feasible because water depths generally dropped off rapidly at these locations. Due to the nature of the boat surveys, less detail is available for these sites. Comparisons with similar sites surveyed by foot, however, allow inferences to be made regarding the intertidal conditions at the boat survey sites. Digital photography was used to document conditions at the majority of the sites, whether covered by foot or by boat. The photographs are provided in Attachment A.

Table 3-1
Lynn Canal SIMS Survey Field Tape Log Summary

Tape	Location	Date	Start Time (UTC)	Stop Time (UTC)	Run Time (min)	Site
1	Berners Bay-Slate Creek	08/18/03	190500	200514	60	Slate 1
2	Berners Bay-Slate Creek	08/18/03	211736	221650	59	Slate 2
3	Berners Bay-Sawmill Cove	08/18/03	233704	002832	51	Sawmill 1
4	Berners Bay-Sawmill Cove	08/18/03	03854	014110	61	Sawmill 2
5	William Henry Bay	08/19/03	155338	165104	57	WHB 1
6	William Henry Bay	08/19/03	170946	181046	60	WHB 2
7	William Henry Bay	08/19/03	182606	192440	58	WHB 3
8	William Henry Bay	08/19/03	192822	201638	49	WHB 4
9	Lynn Canal	08/19/03	220954	231016	60	A1-A2 & STN 1
10	Lynn Canal	08/19/03	235050	000838	18	STN 2
10	Lynn Canal	08/19/03	001422	003734	23	STN 3
10	Lynn Canal	08/19/03	004142	010236	21	STN 4 & STN 5
11	Lynn Canal	08/19/03	014620	023502	49	STN 6, STN 7 & STN 8
12	Katzehin	08/20/03	163748	173322	55	Katzehin 1
13	Katzehin	08/20/03	173926	182942	50	Katzehin 2
13	Katzehin	08/20/03	183820	184824	10	Katzehin 3
14	Katzehin	08/20/03	185938	194920	50	Katzehin 4
15	Low Point	08/20/03	211538	221226	56	T1-1
16	Taiya Inlet	08/20/03	224916	233446	45	STN 9
17	Taiya Inlet	08/20/03	234842	000716	18	STN 10
17	Taiya Inlet	08/20/03	002256	010112	39	T2-1
18	Taiya Inlet	08/20/03	012518	022552	60	T3-1
19	Taiya Inlet	08/21/03	165702	173000	33	T4-1
19	Taiya Inlet	08/21/03	173440	180610	29	T4-1
20	Taiya Inlet	08/21/03	182642	192734	60	STN 12 & STN 13
21	Taiya Inlet	08/21/03	194339	201732	37	STN 11

Notes: UTC – Coordinated Universal Time
min – minutes

Table 3-2
Summary of Geology Data Fields for the Subtidal Survey

Data Field	Description
index	Unique point identification number
date	Month/day/year
time (UTC)	UTC time of frame (hr:min:sec)
substrate	The general substrate of the seabed (rock, veneer, clastics, biogenic)
sed_class	11 classes of clastic sediment
BOULDER	% Pebbles on the seabed by class
cobble	% Cobbles on the seabed by class
PEBBLE	% Boulders on the seabed by class
gravel	% Gravel; sum of pebbles, cobbles and boulders by class
organics	% Of visible wood or organic debris on the seabed by class
shell	% Of coarse shell on the seabed by class
morph	Primary secondary and tertiary morphologic features of the seabed
MAN_MADE	Man-made objects seen on the seabed
geomapper	Last name of individual responsible for the mapping interpretation
comment	Field for recording non-standard information

Note: UTC – Coordinated Universal Time

Table 3-3
Biological Data Fields for Subtidal Survey

Field	Description
index	Unique point identification number
date	Month/day/year
time (UTC)	UTC time of frame (hr:min:sec)
depth	Water depth measured from the sound and NOT corrected for tidal amplitude
VegMap	Code for vegetation map types
veg1	Primary vegetation assemblage on the seabed
cov1	Coverage of the VEG1 vegetation (1, 2, 3, or 4)
veg2	Secondary vegetation assemblage on the seabed
cov2	Coverage of the VEG2 vegetation (1, 2, 3, or 4)
veg3	Tertiary vegetation assemblage on the seabed
cov3	Coverage of the VEG3 vegetation (1, 2, 3, or 4)
tot_cov	Total coverage of vegetation on the seabed
faun1	Primary faunal type
dist1	Distribution of the FAUNA1 type
faun2	Secondary faunal type
dist2	Distribution of the FAUNA2 type
faun3	Tertiary faunal type
dist3	Distribution of the FAUNA3 type
Biomapper	Last name of the biology mapper
COMMENT	Field for non-standard data comments

Note: UTC – Coordinated Universal Time

Table 3-4
Vegetation Classification for the Subtidal Survey

Vegetation Group	Subgroup	Code	Description
Green Algae	Foliose Greens	FOG	Primarily *Ulva*, but also include *Enteromorpha* and *Monostroma.*
	Filamentous Greens	FIG	The various filamentous green/red assemblages (*Spongomorpha/Cladophora* types).
Brown Algae	Fucus	FUC	*Fucus* and *Pelvetiopsis* species groups.
	Sargassum	SAR	*Sargassum* is the dominant and primary algal species.
	Soft Brown Kelps	BKS	Large laminarian bladed kelps, including *L. saccharina* and *groenlandica*, *Costaria costata, Cymathere triplicata.*
	Dark Brown Kelps	BKD	The LUCO chocolate brown group, *L. setchelli, Pterygophora, Lessoniopis. Alaria* and *Egregia* may also be present. Generally more exposed than soft browns.
	Agarum	AGR	*Agarum* is the dominant species but other laminarians may also occur. Generally found deeper than the other Laminarian subgroup.
	Macrocystis	MAC	Beds of canopy forming giant kelp.
	Nereocystis	NER	Beds of canopy forming bull kelp.
Red Algae	Foliose Reds	FOR	A diverse species mix of foliose red algae (*Gigartina*, *Iridea, Rhodymenia, Constantinia*), which may be found from the lower intertidal to depths of 10 meters primarily on rocky substrate.
	Filamentous Reds	FIR1	A diverse species mix of filamentous red algae (including *Gastroclonium, Odonthalia, Prionitis*) which may be found from the lower intertidal to depths of 10 meters, often co-occurirng with the foliose red group described above.
	Filamentous Reds	FIR2	A mix of red algae (primarily *Neoagardhiella* and *Gracilaria*) which grow on shallow, sub-tidal cobble and pebble in fine sand and silt bottoms.
	Halosaccion	HAL	*Halosaccion glandiforme*
	Coralline Reds	COR	Rocky areas with growths of encrusting and foliose forms of coralline algae.
Seagrasses	Eelgrass	ZOS	Eelgrass beds.
	Surfgrass	PHY	Areas of surfgrasses (*Phyllospadix*), which may co-occur with subgroup BKS or BKD above.
No Vegetation		NOV	No vegetation observed.
Cannot Classify		X	Imagery is not clear; classification not possible.

Table 3-5
Faunal Classification with Emphasis on Sessile, Aggregating Species, or Species Groups

Species or Species Complex	Code	Description
Bryozoan Complex	BRY	Bryozoans, Ascidians, sponges - generally on rock substrate.
Tunicates	TUN	Aggregations of tunicates primarily *Ciona* and colonial forms.
Anemone	ANS	Anemones aggregates - strawberry type, generally in high current areas on rock substrates.
	ANM	Aggregations of *Metridium* and other "predator" species.
	TEA	*Tealia* spp.
	ANP	Burrowing anemone (*Pachycerianthes*) on unconsolidated substrates.
Corals	CUP	Cup coral (*Balanophyllia elegans*).
	SPN	Sea pens (*Ptilosarcus gurneyi*).
	SWP	Sea whips (*Balticina septentrionalis*).
Tube worms	TUB	Aggregations of parchment tube dwelling polychaete worms such as *Mesochaetopterus* found in sand and silty substrates.
	TUC	Calcarious tube dwellers such as *Serpula*.
Crabs	CAN	*Cancer* spp. (*C. Magister, C. Gracilis, C. Productus*).
	CRB	Unidentified crab.
Subtidal Clams	GCL	Geoduck clams.
	HCL	Horseclams.
	PCL	Piddock clams.
	BCL	Butter clams.
	OYS	Oyster.
	MUS	Mussels.
	OCL	Other clam species.
Sea Cucumber	CUC	Sea cucumber (*Cucumaria*).
	PAR	California sea cucumber (*Parastichopus californicus).*
Sand Dollars	SDD	Aggregations of sand dollars.
Sea Urchins	RSU	Red sea urchins.
	GSU	Green sea urchins.
	PSU	Purple sea urchin.
Brittle Stars	BRT	Aggregations on sand and silt bottoms may co-occur with burrowing worms.
Sea Stars	STR	Unidentified sea star
	PYC	Sunflower star (*Pycnopodia helianthoides*)
	LUI	Spiny mud star (*Luidia foliatum*)
	HEN	Blood star (*Henricia leviuscula*)
	SOL	Morning sunstar (*Solaster dawsoni*)
	MED	Vermilion star (*Mediaster aequalis*)
	CRO	Rose star (*Crossaster papposus*)
	PBR	Spiny pink sea star (*Pisaster brevispinus*)

Table 3-5 (continued)
Faunal Classification with Emphasis on Sessile, Aggregating Species, or Species Groups

Species or Species Complex	Code	Description
Sea Stars (continued)	POR	Ochre sea star (*Pisaster ochraceus*)
	EVA	Mottled sea star (*Evasterias troschelii*)
Blue green bacteria (alga)	BEG	*Beggiatoa* spp.
Unknown	UNK1	Macro fauna visible but cannot be identified
No Fauna	NOF	No fauna observed
Infauna "holes"	HLM	Mounded worm, clam or crustacean holes but species or species group cannot be distinguished.
	HLF	Unmounded (flat) worm or clam holes but species or species group cannot be distinguished.

Table 3-6
Fish Classification for the Subtidal Survey

Fish	Code	Description
Unidentified Fish	FSH	Unidentified Fish
Flatfish	FTF	Unidentified Flatfish
Dogfish	SDG	Spiny Dogfish (*Squalus acanthias*)
Rockfish	CRK	Copper Rockfish (*Sebastes caurinus*)
Skate	SKA	Big Skate (*Raja binoculata*)

Table 3-7
Intertidal Survey Evaluation Summary

Section ID (Location)	Site Status	Survey Date	Survey Time Range (military time) [1]	Tide Level (feet) [2]	Survey Method	Weather	Estimated Total Section Length (feet) [3]	Estimated Length Surveyed (feet)	General Shoreline Classification	Geomorphology: Slope (low [flat]-med-high [steep]); Wave exposure (low-med-high)	General Observations of Intertidal Zone (ITZ)
EIT 1	No longer within alignment	26-Aug-03	05:42 - 06:05	1.4 to 0.3	Foot & Boat	Sun	150	50 by foot, 100 by boat	**Sediment Beach** (Boulder, cobble, & sand)	Slope: 30% low, 70% med; Wave: low	Kasidaya Creek. Mussel beds.
EIT 2	No longer within alignment	26-Aug-03	06:17 - 06:29	-0.1 to -0.5	Foot & Boat	Sun	250	100 by foot, 50 by boat	**Sediment Beach** (Boulder, cobble, & sand)	Slope: 100% low; Wave: med	Mussels on boulders, lower ITZ.
EIT 3	No fill in intertidal zone	26-Aug-03	06:33 - 06:38	-0.5 to -0.7	Foot & Boat	Sun	250	50 combined foot and boat	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 80% low, 20% med; Wave: med	Dense mussel beds. Typical zonation similar to EIT 2.
EIT 4	No longer within alignment	26-Aug-03	06:49 - 06:51	-0.89 to -0.91	Boat	Sun	150	150	**Bedrock Cliff / Vertical Face**	Slope: 100% high	Extremely dense mussel beds, narrow bands of Fucus and barnacles, *Verrucaria*. Typical zonation similar to EIT 3.
EIT 5	No longer within alignment	26-Aug-03	06:52 - 06:55	-0.92 to -0.95	Boat	Sun	100	100	**Bedrock Cliff** (Rock face)	Slope: 100% high	Very similar to EIT 4, narrow bands of Fucus and mussels, *Verrucaria*.
EIT 6	Fill to 8 feet elevation	26-Aug-03	07:01 - 07:03	-1.00 to -1.01	Boat	Sun	100	100	**Sediment Beach** (Steep boulders)	Slope: 100% high	Very similar to EIT 4, narrow bands of Fucus and mussels, *Verrucaria*.
EIT 7	No longer within alignment	26-Aug-03	07:05 - 07:07	-1.02 to -1.03	Boat	Sun	75	75	**Bedrock Cliff & Sediment Beach** (Boulders)	Slope: 80% med, 20% high; Wave: med	Steep boulder beach leading to rock face. Very similar to EIT 5.
EIT 8	No longer within alignment	26-Aug-03	07:25 - 07:35	-1.0 to -0.8	Foot	Sun	200	50	**Sediment Beach** (Cobble & gravel)	Slope: 80% med, 20% high; Wave: med	Less Fucus here – may be more protected; sea lion scat on boulder beach/rock outcrop north of site. Dungeness crab shells observed on shore.
EIT 9	Fill in intertidal zone	26-Aug-03	07:38 - 07:42	-0.80 to -0.77	Foot	Sun	200	10	**Sediment Beach** (Boulders)	Slope: 100% high	Extensive barnacle cover.
EIT 10	No fill in intertidal zone	26-Aug-03	08:32 - 08:44	0.8 to 1.3	Foot	Sun	550	550	**Sediment Beach** (Boulder & cobble)	Wave: med	Numerous very small littorines (*Littorina sitkana*).
EIT 11	Fill into water	26-Aug-03	09:01 - 09:06	2.2 to 2.5	Boat	Sun	500	500	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 20% med, 80% high	Typical zonation similar to other boulder/cobble sites. Transitions from steep boulder beach to less steep cobble beach. Ferry terminal site, contiguous to south.
EIT 12	Uplands	26-Aug-03	09:24 - 09:47	3.5 to 5.0	Foot	Sun	1,000	1,000	**Wetland**	N/A	Not intertidal, see photos. Observed grasses, sedges, eagles chattering, and saltwater channels.
EIT 13	Bridge and approaches fill in intertidal zone	27-Aug-03	07:05 - 07:24	-1.4 to -1.8	Foot	Cloudy	4,500	All but river. Extent of foot survey: 59° 11' 79", 135° 17' 16" (main river channel)	**Sediment Beach** (Cobble, sand, & gravel)	Slope: 100% low; Wave: low	Broad sandy beach with gravel. Cobbles in places with clumps of Fucus on top. Many tidal channels. Small fish in tidal pools.
EIT 14	Fill down to 11 feet	27-Aug-03	07:26 - 07:36	-1.8 to -1.9	Foot	Cloudy	550	550	**Sediment Beach** (Cobble, sand, gravel, & mud)	Slope: 100% low; Wave: low	Large stream with waterfall, river otter tracks.
EIT 15	No longer within alignment	27-Aug-03	07:50 - 07:55	-2.01 to -2.00	Foot	Cloudy	250	250	**Sediment Beach** (Cobble, sand, & gravel)	Slope: 100% low; Wave: low	Gravel/cobble beach, numerous interbedded mussels. Long, low angle beach, mussels also on rock face at back of beach. Small fish in tidal pools. King crab carcasses were observed on shore.
EIT 16	No longer within alignment	27-Aug-03	08:35 - 08:38	-1.21 to -1.24	Boat	Cloudy	600	600	**Bedrock Cliffs** (Platform)	Slope: 20% med, 80% high; Wave: med	Just past Gran Pt. sea lion haulout. Four sea lions (cows) present on site. Could only approach to within 100 feet. No evidence of sea lion disturbance. Typical rocky intertidal zonation.

Table 3-7 (continued)
Intertidal Survey Evaluation Summary

Section ID (Location)	Site Status	Survey Date	Survey Time Range (military time) [1]	Tide Level (feet) [2]	Survey Method	Weather	Estimated Total Section Length (feet) [3]	Estimated Length Surveyed (feet)	General Shoreline Classification	Geomorphology: Slope (low [flat]-med-high [steep]); Wave exposure (low-med-high)	General Observations of Intertidal Zone (ITZ)
EIT 17	No longer within alignment	27-Aug-03	08:43 - 08:46	-1.0 to -0.7	Boat	Cloudy	400	400	**Bedrock Cliffs**	Slope: 100% high; Wave: med	Typical zonation. Small waterfall.
EIT 18	Fill at 20 feet	27-Aug-03	08:50 - 08:53	-0.6 to -0.5	Boat	Cloudy	200	200	**Bedrock Cliffs**	Slope: 100% high; Wave: med	Steep boulder beach. Evidence of sea lion use.
EIT 19	Fill at 15.8 feet	27-Aug-03	09:20 - 09:24	0.7 to 1.0	Boat	Cloudy	300	300	**Bedrock Cliffs**	Slope: 100% high; Wave: med	Steep rock face leading to steep boulder beach. Sea lion observed off bow of boat. Typical zonation.
EIT 20	Fill at 5.5 feet	27-Aug-03	09:27 - 09:30	1.09 to 1.14	Boat	Cloudy	300	300	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 100% high; Wave: med	Moderate angle beach. Small creek. Pocket beach w/ gravel, cobbles, and boulders to the south.
EIT 21	Fill at 10 feet	27-Aug-03	09:48 - 10:15	2.4 to 4.3	Foot & Boat	Cloudy	5,500	150 by foot, remainder by boat.	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 10% low, 90% med; Wave: med	Long site – cobble beach & gravel. South of waterfall. Dense mussels on boulders, dense Fucus on steep boulder beach to south. Small fish in tidal pools.
EIT 22	Fill at 5 feet	28-Aug-03	06:29 - 06:41	2.3 to 1.3	Boat	Sun	600	600	**Bedrock Cliffs & Sediment Beach** (Boulder & cobble)	Slope: 40% med, 60% high; Wave: med	Mussel spats on boulders.
EIT 23	Fill at 17.6 feet	28-Aug-03	06:45 - 06:53	1.3 to 0.6	Boat	Sun	600	600	**Bedrock Cliffs & Sediment Beach** (Boulder)	Slope: 20% med, 80% high; Wave: med	Very similar to EIT 22. Steep boulder beach.
EIT 24	Fill at 21 feet	28-Aug-03	06:55 - 06:58	0.6 to 0.3	Boat	Sun	700	700	**Bedrock Cliffs & Sediment Beach** (Boulder)	Slope: 50% med, 50% high; Wave: med	Very steep boulder beach. Dense coralline algae. Typical zonation.
EIT 25	Fill at 10 feet	28-Aug-03	07:00 - 07:15	0.2 to -0.7	Boat	Sun	1,500	1,500	**Bedrock Cliffs & Sediment Beach** (Boulder)	Slope: 50% med, 50% high; Wave: med	Beach begins with steep rock face. High angle boulder beach. Slide area. Very similar to EIT 24. Very dense mussel spat at waterline.
EIT 26	Fill at 9.9 feet	28-Aug-03	07:17 - 07:25	-0.77 to -1.1	Boat	Sun	1,500	1,500	**Bedrock Cliffs & Sediment Beach** (Boulder)	Slope: 80% med, 20% high; Wave: med	Boulder beach with steep outcrops.
EIT 27	Alignment moved uphill out of fill	28-Aug-03	07:28 - 07:40	-1.2 to -1.4	Foot & Boat	Sun	400	400 combined foot and boat	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 50% low 50% med; Wave: med	Small fish in ponds.
EIT 28	Fill at 18.8 feet	28-Aug-03	07:42 - 07:45	-1.8 to -1.9	Boat	Sun	500	500	**Bedrock Cliffs & Sediment Beach** (Boulder)	Slope: 100% high; Wave: med	Rock outcrop with boulders. Dense coralline algae.
EIT 29	No longer within alignment	28-Aug-03	07:50 - 07:55	-2.1 to -2.2	Boat	Sun	750	750	**Sediment Beach** (Boulder)	Slope: 100% med; Wave: med	Dense barnacles; minimal Fucus and *Alaria* spp. – could be more exposed.
EIT 30	No longer within alignment	28-Aug-03	07:55 - 08:05	-2.2 to -2.4	Boat	Sun	200	200	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 50% low, 50% med	Dense mussel spat in lower ITZ.
EIT 31	No longer within alignment	28-Aug-03	08:10 - 08:15	-2.45 to -2.50	Boat	Sun	450	450	**Sediment Beach** (Boulder & cobble)	Slope: 100% med; Wave: med	Minimal *Alaria* spp., dense coralline algae.
EIT 32	No longer within alignment	28-Aug-03	08:18 - 08:20	-2.52 to -2.52	Boat	Sun	100	100	**Bedrock Cliffs & Sediment Beach** (Boulder)	Slope: 100% high; Wave: med	Very short site. Boulder rock face and typical zonation.
EIT 33	No longer within alignment	28-Aug-03	08:20 - 08:21	-2.52 to -2.52	Boat	Sun	100	100	**Bedrock Cliffs**	Slope: 100% high; Wave: med	Very short site. Rock/cliff face. Dense *Alaria* spp. and typical zonation as with EIT 32.
EIT 34	No longer within alignment	28-Aug-03	08:21 - 08:23	-2.52 to -2.52	Boat	Sun	200	200	**Bedrock Cliffs**	Slope: 100% high; Wave: med	Very short site. Rock face. Typical zonation.

Table 3-7 (continued)
Intertidal Survey Evaluation Summary

Section ID (Location)	Site Status	Survey Date	Survey Time Range (military time) [1]	Tide Level (feet) [2]	Survey Method	Weather	Estimated Total Section Length (feet) [3]	Estimated Length Surveyed (feet)	General Shoreline Classification	Geomorphology: Slope (low [flat]-med-high [steep]); Wave exposure (low-med-high)	General Observations of Intertidal Zone (ITZ)
EIT 35	Fill at 9.3 feet	28-Aug-03	08:25 - 08:38	-2.52 to -2.49	Foot & Boat	Sun	300	300 combined foot and boat	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 100% high; Wave: med	Moderately steep boulder beach. Dense urchins and limpets. Typical zonation. Stream nearby.
EIT 36	Fill at 8.0 feet	28-Aug-03	08:55 - 09:27	-2.2 to -1.0	Foot	Sun	2,200	2,200	**Sediment Beach** (Boulder, cobble, & gravel)	Slope: 100% low; Wave: med	Gravel/cobble/boulder beach, low angle beach. Small fish in ponds. Avalanche chute area.
EIT 37	Fill at 13.5 feet	28-Aug-03	09:28 - 09:41	-1.0 to -0.30	Foot	Sun	400	400	**Sediment Beach** (Cobble)	Slope: 100% low; Wave: med	Small stream crosses the site. More diversity at the stream.
EIT 38	No fill in intertidal zone	28-Aug-03	09:46 - 09:50	-0.05 to -0.19	Foot	Sun	200	200	**Sediment Beach** (Cobble & gravel)	Slope: 100% low; Wave: med	Mouth of fairly large stream with typical intertidal zonation of other sites. Banks of stream are washed clean – very fast stream.
EIT 39	No longer within alignment	28-Aug-03	10:10 - 10:16	1.5 to 1.8	Foot	Sun	800	200	**Sediment Beach** (Cobble)	Slope: 100% low; Wave: med	Boulder/cobble low angle lens fairly exposed.
EIT 40	No longer within alignment	28-Aug-03	10:24 - 10:30	2.4 to 2.9	Foot	Sun	500	300	**Sediment Beach** (Cobble)	Slope: 100% low; Wave: med	Cobble, low angle beach.
EIT 41	Berners/Lace rivers	Not surveyed (Berners/Lace rivers)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WHB	Ferry terminal site	29-Aug-03	07:18 - 08:15	1.5 to -1.7	Foot	Sun	3,000	3,000	**Sediment Beach** (Boulder, cobble, sand, gravel, & rocky outcrops)	Slope: 100% low; Wave: low/med	Ferry terminal site. Extremely rich intertidal area. Sand gravel beach changing to boulders. Sculpins in tidal pools, fish egg mass.
SLA-1	Ferry terminal site	29-Aug-03	09:09 - 09:43	-2.4 to -1.7	Foot	Sun	1,700	1,300	**Sediment Beach** (Cobble, sand, gravel, & mud)	Slope: 100% low; Wave: med	Ferry terminal site. Mud/silty bottom with occasional boulders/cobbles. Rock outcrop with typical zonation. Crescent gunnels present.
SAW	Ferry terminal site	29-Aug-03	11:15 - 11:18	3.9 to 4.1	Boat	Sun	3,500	3,500	**Sediment Beach** (Boulder, cobble, sand, & gravel)	Slope: 100% low; Wave: low/med	Ferry terminal site. Typical zonation on rock outcrops and boulders. Minimal life on cobbles at center of beach.
EIT 42	Antler River	29-Aug-03 (twice)	11:50 - 11:55 13:30 - 14:00	11.8 to 12.2 14.7 to 16.4	Boat	Cloudy	2,500	N/A	(Antler River)	N/A	Photos taken at low tide and 1 hr prior to high tide.
EIT 43	No longer within alignment	29-Aug-03	13:04 - 13:06	12.9 to 13.0	Foot	Cloudy	300	300	**Wetland / Tidal Slough**	Slope: 100% low; Wave: low	Wetlands area. Very similar to EIT 44 and -46. Slough with sandy bottom and small fish. No tidal influence. Numerous bear signs (tracks, burrows for roots, scat).
EIT 44	No longer within alignment	29-Aug-03	13:01 - 13:03	12.6 to 12.8	Foot	Cloudy	250	250	**Wetland / Tidal Slough**	Slope: 100% low; Wave: low	Wetlands area. Very similar to EIT 45. Small fish present. No tidal influence.
EIT 45	No longer within alignment	29-Aug-03	12:53 - 12:55	12.1 to 12.2	Foot	Cloudy	250	250	**Tidal Slough**	Slope: 100% low; Wave: low	Large dead fall. Tidal influence not likely. Small fish and bear sign observed.
EIT 46	No longer within alignment	29-Aug-03	12:28 - 12:34	10.0 to 10.5	Foot	Cloudy	500	500	**Tidal Slough**	Slope: 100% low; Wave: low	Tidally influenced slough. Surrounded by saltmarsh grasses. Small fish present.

Notes: Biologists Sue Ban and Rich Kleinleder were field crew on all sites.
[1] AST-Alaska Standard Time
[2] Measurement taken at Taiya Inlet, near Skagway.
[3] Lengths measured from GIS map.

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4.0 AFFECTED ENVIRONMENT

4.1 2003 Subtidal Field Study Results

Twelve of the 31 subtidal surveys in 2003 were located at potential ferry terminal sites; the remaining 19 subtidal sites are locations that may be impacted by placement of fill, or were chosen as representative of sites where sidecasting could occur. A section of Sawmill Cove, mostly outside of the ferry terminal site, with one line perpendicular to the shore and near the ferry terminal, was also surveyed by NMFS on August 31, 2004, with an underwater camera, as described in Sec. 4.1.1.1. Separate discussions of the results of the subtidal study are provided for each of the four ferry terminal sites (Sawmill Cove, Slate Cove, Katzehin, and William Henry Bay) in Section 4.1.1. The remaining 19 subtidal sites are discussed in Section 4.1.2, and details of the results for these sites are presented in tabular form in Table 4-1.

4.1.1 Potential Ferry Terminal Sites

4.1.1.1 Sawmill Cove

The 2003 subtidal survey extended from the intertidal zone to depths of 100 feet. The area surveyed was approximately 500 feet by 1,600 feet, with 3,000 classified images in the survey grid. The towed video imagery extended into the intertidal zone up to the +10 feet tidal elevation. Figure 4-1 shows the tracklines of the subtidal video produced during the survey.

At Sawmill Cove, the seabed is comprised almost exclusively of clastic sediment (muds, sand, sand gravels), although there may be some till or bedrock cropping out on the seabed in one location. Gravel (>0.10 inches to boulders) content is highest in the intertidal zone (>80 percent) and drops off rapidly in the offshore where sands and muds predominate. No bedforms were noted on the imagery. A single piling (60 feet water depth) was the only anthropogenic feature noted in the imagery. No concentrations of organic debris (e.g., bark, detritus) were noted. Shell fragments composed up to 30 percent of the seabed on some of the northern portions of the site.

Based on the 2003 survey, vegetation cover was closely linked to gravel presence; therefore, vegetation cover dropped off rapidly in the offshore. Maximum vegetation covers were <25 percent in the intertidal zone and <5 percent in the subtidal. Intertidal assemblages of vegetation included bladed kelps, foliose red algae, foliose green algae, filamentous green algae, and rockweed. The only subtidal vegetation noted by the interpreters of the 2003 survey images was a small patch of bladed kelp located in the northern survey area. No eelgrass or stalked kelp (such as *Macrocystis integrifolia)*, or floating kelp (such as *Nereocystis luetkeana*) was noted. See additional information about Sawmill Cove in general at the end of this section provided by further subtidal survey of the cove conducted in 2004 by NMFS.

The survey identified barnacles and mussels as the dominant intertidal fauna with unidentified anemones noted throughout the lower intertidal zone. In the subtidal zone, one location of orange sea pens *(Ptilosarcus gurneyi*) was noted in the northern third of the site (estimated at an area of 21,500 square feet; depth ranging from 50 to 80 feet). These Pennatulacean corals are living marine substrates and are defined by the Act as Habitat Areas of Particular Concern (HAPC) because of their ecological importance, sensitivity to disturbance, and rarity. Three Federally managed species have been observed in surveys of similar soft coral groves, all in their juvenile stage: walleye pollock, rock sole, and yellowfin sole. In addition, juvenile red king crabs use these groves for rearing. At this site in particular, mobile species were observed on the imagery and recorded: 10 unidentified crabs, 21 unidentified fish, and 19 flatfish. The sediment veneer location (either till or bedrock) appears to be the location of a bivalve concentration and bryozoan complex; as the zone only showed up on a single survey line, the area cannot be accurately estimated but is thought to be roughly less than 2,700 square feet.

The subtidal seabed was mostly sand and muddy sand. There did not appear to be any aggregations of mobile species. Orange sea pens, a bryozoan complex, and unidentified bivalves appear to be the only unique aggregations within the survey area.

On August 31, 2004, personnel from NMFS conducted an additional site visit to Sawmill Cove, including a video survey of a portion of the subtidal area of the cove, traversing the proposed Sawmill Cove ferry terminal site using a lowlight (0 lux) underwater, black and white television camera towed off the bottom and equipped with infrared l.e.d. lights, a wide-angle (15 mm) lens, and 100 feet of steel cable. The survey was conducted in a a straight line from the northwest rocky point to the point near to and south of the ferry terminal site, and from that point, a straight line to the southeast rocky point at the outlet of Sawmill Creek. The subtidal camera tow covered depths from –10 feet to –70 feet. The middle portion of the tow was inaccessible to the camera because of depth (deeper than 70 feet). The NMFS underwater camera survey area and the 2003 subtidal survey are different locations and orientations to the shoreline. The NMFS surveyed one line in a perpendicular orientation to the shoreline, near the proposed Sawmill Cove ferry terminal location, and the 2003 subtidal survey covered an area parallel to the shoreline including perpendicular tracking back and forth within that area.

This survey identified rocky substrate on both headlands and then a soft sand/shell or mud substrate with occasional larger cobble. The cobble provided attachment sites for the holdfasts of large-bladed kelp. Vegetation consisted of dense *Fucus* on the rocky points which extended to about the 0 foot tidal elevation. In the low intertidal zone, rock weed was interspersed with both *Lamanaria saccharina* (sugar kelp) and *Agarum clathratum* (shotgun or sieve kelp). Lamanaria was sparsely but evenly distributed throughout the subtidal survey site. Fish species observed included yellowfin sole, rock sole, gunnels, snake prickleback, sculpin, sand lance, and a large school of young Pacific herring. Multiple rose anemones (*Urticina lofotensis*) were observed in deeper waters. Siphons of many mollusks were observed protruding from the substrate but were not identified to species.

4.1.1.2 Slate Cove

The subtidal survey extended from the intertidal zone to depths of 125 feet. The area surveyed was approximately 980 feet by 2,600 feet, with 1,779 classified images in the survey grid. The towed video imagery extended into the intertidal zone up to the +6 tidal elevation. Figure 4-2 depicts the location of the video tracklines.

The site has a highly uniform seabed consisting of mud. A few boulders and cobbles were observed at the southern, intertidal portion of the survey. No bedforms were noted. Trace levels of organics (bark and detritus) and shell fragments were noted adjacent to the shore. A single metal pipe was the only anthropogenic feature noted.

No seabed vegetation was seen in the subtidal imagery. Sparse fauna was observed including a few unidentified fish, a few flatfish, and a single anemone. No sea grasses or kelps were noted in the subtidal zone at this location. In addition, no aggregations of epifauna were noted.

4.1.1.3 Katzehin

The subtidal survey extended from the intertidal zone to depths of 85 feet. The area surveyed was approximately 660 feet by 2,600 feet, with 1,050 classified images in the survey grid. The towed video imagery extended into the intertidal zone up to the +10 feet tidal elevation. Figure 4-3 shows the video tracklines recorded at the site. Visibility was extremely poor at this site, frequently less than 1 foot, so a large portion of the survey points could not be classified (~75 percent). However, the classified points were widely distributed over the study area, and all classified points were extremely uniform. All subtidal trends at this site were consistent with a uniformly featureless muddy seabed.

The site has two distinct environments: a boulder-cobble-pebble-dominant intertidal zone and a muddy subtidal zone. No bedforms or man-made features were noted. No shell or organic concentrations were noted.

Vegetation was observed in the intertidal zone, but not in deeper water areas. Stalked kelps *(Alaria spp.)* occurred along one section of the intertidal. Foliose green algae probably *(Ulva spp.*) filamentous red algae, and *Fucus gardnerii (Fucus)* were visible in a few of the intertidal images.

No seabed vegetation was seen in the subtidal imagery. Minimal fauna was observed including a few unidentified fish, a few flatfish, and a single anemone. No sea grasses or kelps were noted in the survey and there were no aggregations of epifauna.

4.1.1.4 William Henry Bay

The subtidal survey extended from the intertidal zone to depths of 70 feet. The area surveyed was approximately 1,300 feet by 3,000 feet, with 6,257 classified images in the survey grid. The towed video imagery extended into the intertidal zone up to the +10 feet tidal elevation. Figure 4-4 depicts the video tracklines recorded at William Henry Bay. Visibility was excellent at this site.

Gravels are limited to the shallow nearshore (<6 feet) and intertidal zone. The gravel includes boulder and cobbles along the western shore and mostly pebbles at the southern head of the bay. Fines rapidly increase in the offshore direction. Sands and muds extend to the 30 to 50 feet depth, with muds predominant in deeper water. No significant trends in shell cover were noted; however, there is a pocket of organic debris located in the southeastern corner of the site. No bedforms were noted. Seven anthropogenic objects were observed (a bottle, a can, two metal objects, and three unidentified objects).

Vegetation is restricted to depths of less than 50 feet and extends into the intertidal zone. Highest covers (25 to 75 percent) occur in the intertidal zone. Intertidal algae that were mapped from the towed video include bladed kelps *(Laminaria spp.),* coralline red algae, rockweed, filamentous red algae, and foliose red algae. The subtidal cover is in the trace to 5 percent cover category and consists primarily of bladed kelp and filamentous red algae. Bladed kelps were common but of low density on the northern, subtidal portion of the site. No stalked kelps or eelgrass were observed.

The intertidal zone included barnacles *(Balanus/Semibalanus spp.),* blue mussels *(Mytilus trossulus),* and green urchins *(Stronglyocentrotus droebachiensis*). The green urchins extend into the shallow subtidal (<6 feet). Sea cucumbers (either *Cucumaria spp*. or *Parastichopas californicus*) were very dense at the northern end of the site (0 to 33 feet depths). Orange sea pens were common in the deeper (33 to 65 feet), northern part of the site. Sea whips were also noted in the deep, northeastern corner (>60 depths). As described for Sawmill Cove, both sea pens and sea whips are living marine structures that are considered HAPC because of their ecological importance, sensitivity to disturbance, and rarity. They often provide habitat for Federally-managed species. Anemones were common in depths greater than 33 feet. Mottled sea stars were common in the shallow subtidal zone (3 to 20 feet depths) throughout the site.

Crabs are not particularly common (only 18 were seen), but flatfish are common throughout the site in depths >23 feet. Forty-four flatfish were counted in the surveyed area. The site was the richest faunal site mapped. Green urchins, sea cucumbers, sea pens, sea stars *(Asteriidae spp.),* anemones, and flatfish are considered common at the site.

4.1.2 Other Sites

Table 4-1 provides physical and biotic descriptions of the 19 other sites investigated as part of the subtidal survey. The location of these sites, which may be impacted by fill placement during highway construction or are typical of sites that may be impacted by sidecasting, are shown on Figure 3-1 and Attachment B.

The table indicates that while subtidal vegetation (algae) was observed at many of the sites, none of the sites supported eelgrass beds or areas of stalked kelps. Unidentified fish were observed at all of the Lynn Canal sites, and shrimp and fish were observed at several of the Taiya Inlet sites.

4.2 2003 Intertidal Field Study Results

The results of the 2003 intertidal study are divided into separate discussions for the following:

- Potential ferry terminal sites – four sites
- Sites affected by fill placement and/or typical sidecast sites – 45 sites

Table 4-3 provides a comprehensive list of species observed during the intertidal field survey.

4.2.1 Potential Ferry Terminal Sites

The four ferry terminal sites were also investigated as part of the intertidal study. The sites are located at Sawmill Cove (SAW) and Slate Cove (SLA-1), near the mouth of the Katzehin River (EIT 11), and at William Henry Bay (WHB) on the west side of Lynn Canal (see Figure 3-1). Detailed maps of the intertidal survey sites can be found in Attachment B.

4.2.1.1 Sawmill Cove

The proposed ferry terminal site at Sawmill Cove on Figure 3-1 and Figure B-11 (in Attachment B) consists of a gravel cobble beach with typical zonation on rock outcrops and boulders at the edges of the cove. The beach itself supports minimal visible life (i.e., a few barnacle spat were observed, but no distinct *Fucus* or *Mytilus* bands). Based on a NMFS field visit on August 31, 2004, covering a straight line from the outside points of Sawmill Cove, outside of the ferry terminal site, NMFS reported the intertidal vegetation consisted of dense *Fucus*, or rockweed, on the rocky points. In the low intertidal zone, rockweed was interspersed with *Lamanaria saccharina* and *Agarum clathratum* (both large-bladed kelp). The 2004 NMFS survey found *Lamanaria* to be distributed throughtout the survey site and, although sparse, was persistent and evenly distributed and would provide suitable and productive spawning substrate for Pacific herring.

It is likely that gammarids and isopods inhabit the spaces between and beneath the gravel and cobbles. Fish species observed by NMFS in 2004 included yellowfin sole, rock sole, gunnels, pricklebacks, sculpin, sand lance, and a large school of young Pacific herring. The cove is located more than a mile from the mouth of Sawmill Creek, which is a highly productive area and supports anadromous fish.

4.2.1.2 Slate Cove

The Slate Cove Ferry Terminal site is situated over 2,000 feet from the mouth of Slate Creek (see Figure 3-1 and Figure B-9 in Attachment B). The beach at the site consisted of a mud silt base with a veneer of gravel, cobbles, and boulders in places. Many clam holes were evident in the mud at and near the water level, and numerous empty *Macoma balthica* shells were observed. Mussels, rockweed, and barnacles were attached in clumps on most of the cobbles and boulders, along with clumps of sea lettuce. Rock outcrops at locations along the beach exhibited the typical intertidal zonation consisting of bands of *Fucus*, *Mytilus*, and barnacles. Other types of algae observed on the outcrops, boulders, and larger cobbles included the filamentous brown algae, *Pilayella littoralis*, and the filamentous green algae *Enteromorpha intestinalis*. Littorines and the mask limpet *(Tectura persona*) were observed along with the burrowing anemone *Anthopleura artemisia*. Gammarid amphipods and the isopod *Idotea wosnesenskii* were observed under rocks and driftwood, along with the crescent gunnel *Pholis laeta*. Other small fish and sculpins were observed in small tidal pools.

Slate Creek is identified as an anadromous stream supporting a population of chum salmon, and pink and coho salmon have been observed there in the past (see the *Anadromous and Resident Fish Streams Technical Report*). Therefore, Slate Creek is identified as freshwater EFH for chum and other salmon, and could be spawning or rearing habitat for other fish species also.

4.2.1.3 Katzehin

The Katzehin Ferry Terminal site is located adjacent to an intertidal site investigated at EIT 11 (see Figure 3-1 and Figure B-4 in Attachment B). The site consists of a steep, high-angle boulder/cobble/gravel beach that was observed from the boat. Typical zonation patterns of barnacles/mussels and *Fucus* were observed on the boulders and rock outcrops. *Ulva fenestrata* (sea lettuce) and *Acrosiphonia spp.* (Arctic sea moss) were also observed. Moving south, the site transitions from a steep boulder beach to a less steep cobble beach. Due to the steepness of the beach and the potential wave exposure, this site is less productive as EFH than other more protected coves.

4.2.1.4 William Henry Bay

William Henry Bay is located on the west side of Lynn Canal. Two anadromous fish streams drain into the bay: William Henry Creek (pink and chum salmon) and the Beardslee River (coho, pink, & chum salmon, and Dolly Varden). Evidence of spawning pink salmon was observed in the bay and at the Beardslee River. The intertidal zone between the two drainages was investigated on foot as part of this study.

The intertidal zone at William Henry Bay is a biologically rich and diverse area. The site consists of a sand, gravel, cobble, and boulder beach changing to boulders away from the head of the bay. Typical zonation patterns as previously described were observed on the rock outcrops and larger boulders. Numerous tidal pools were evident among the boulders and cobbles on the main part of the beach, and dense beds of mussels were interbedded in the gravel areas.

A small freshwater stream bisects the intertidal zone between the two larger streams and supports dense patches of *Ulva fenestrata, Cladophora spp.,* and *Enteromorpha intestinalis*. Sculpins and other small fish were observed in tidal pools near the stream, and throughout the site. Gammarid amphipods, hermit crabs, and littorine snails were observed in the upper and middle intertidal zones. Lower in the intertidal zone, burrowing anemones, limpets, green urchins, and crumb-of-bread sponges were noted. At or near the water line, coralline algae and *Alaria spp.* were dense on the boulders. The brown algae known as chocolate pencils *(Chordaria flagelliformis*) was observed.

This site is likely used by the EFH species for spawning, rearing, and/or growth to maturity. Not only are there two streams draining into the bay nearby that have been cataloged as anadromous by the OHMP, but also salmon, sculpins and other small fish were observed in the intertidal zone. In addition, numerous clumps of fish eggs, likely sculpin eggs, were found in crevices and tidal pools in the lower intertidal zone. This is clearly habitat used for spawning, rearing, and growth to maturity by several EFH-designated species.

4.2.2 Fill/Sidecasting Sites

Most of the sites visited (45 of 49) were identified by DOT&PF as possible fill locations for highway construction, or are representative of typical sites where sidecasting could occur. However, subsequent to the intertidal survey conducted in August 2003, the proposed highway alignment was changed in order to avoid placing fill at many of these sites. Therefore, the following locations investigated during the August 2003 survey are no longer potentially affected by placement of fill:

- EIT 43, 44, 45, and 46 – located in Berners Bay
- EIT 38, 39, and 40 – near Comet
- EIT 29, 30, 31, 32, 33, and 34 – south of Eldred Rock
- EIT 27 – south of Eldred Rock
- EIT 15, 16, and 17 – north of Yeldagalga Creek
- EIT 10 – north of the Katzehin Ferry Terminal site
- EIT 1, 2, 3, 4, 5, 7, and 8 – in Taiya Inlet. Note: no fill is proposed for these sites, but several sites (such as EIT 4 and 5) are representative of potential sidecast locations. Substrate and habitat at these sites are expected to be similar to any other sites along Taiya Inlet that could be impacted by sidecast materials.
- EIT 41 and 42 – river crossings for the Berners/Lace and Antler rivers have been moved upstream and out of the estuary/intertidal zone.

The remaining sites where fill would be placed can be further subdivided for ease of discussion:

- Sediment beaches consisting of some combination of boulder, cobble, gravel, sand, and/or mud – EIT 6, 9, 11 (Katzehin Ferry Terminal site), 13, 14, 20, 21, 27, 35, 36, 37, and 38
- Bedrock cliffs and vertical rock faces – EIT 18 and 19
- Combinations of beaches and bedrock – EIT 22, 23, 24, 25, 26, and 28
- Wetland or slough/marsh areas – EIT 12
- West side fill locations – not investigated during the July 2003 study

Figure 3-1 shows the general site locations; detailed maps of the site locations can be found in Attachment B.

4.2.2.1 Sediment Beaches

Twenty-two of the fill/sidecasting sites visited during the study are comprised of sediment beaches with varying combinations of boulder, cobble, gravel, sand, and/or mud. As expected on rocky coastlines, species observed at these sites form conspicuous bands or belts of varying widths. Characteristics of the zonation and types of organisms observed can differ greatly between locations and are dependent upon many variables including wave exposure and slope of the beach. Standard surveying techniques designate three zones to describe the intertidal slopes: high, mid, and lower.

The following discussion provides a generalized description of organisms found in the high, mid, and lower intertidal zones at sediment beach sites in Lynn Canal. Photographs depicting each site are provided in Attachment A.

High intertidal – At sediment and boulder beaches on both exposed and more protected areas a nearly continuous band of the black seaside lichen *Verrucaria spp*. was observed on boulders in the very highest intertidal zone. Animals found in the high intertidal zone at most of these shores included the Sitka periwinkle *(Littorina sitkana*), the checkered periwinkle *(L. scutulata*), and scattered individuals of the common acorn barnacle *(Balanus glandula*). *B. glandula* becomes more continuous moving toward the water line, eventually forming distinct bands in the mid intertidal zone. Another barnacle, *Semibalanus balanoides* is found in the high intertidal zone, particularly in areas where freshwater streams are noted. Limpets such as the mask limpet *(Tectura persona*) were also observed. The isopod, *Ligia pallasii*, was observed under rocks and in clumps of green sea hair. At many sites hermit crabs *(Pagurus spp*.) were observed at the lower edge of the high intertidal zone and into the mid intertidal zone.

Mid intertidal – On these rocky shores, the mid-intertidal zone is characterized by an extensive band of *Fucus*. Also found throughout the zone were scattered clumps of filamentous green algae *(Arcosiphonia arcta* and *Cladophora spp*.), brown algae *(Pilayella littoralis*), and sea lettuce *(Ulva fenestrata*). Mid intertidal animals observed during this study include the Sitka periwinkle, which ranges downward from the upper intertidal zone, and the common acorn barnacle, which becomes more dense in this zone, forming distinct bands beginning at the top of the mid intertidal zone. A few thatched barnacles *(Semibalanus cariosus*) and more dense bands of *S. balanoides* were also encountered in this zone. Immediately below the barnacle band, dense beds or bands of blue mussels were observed at many locations. Arthropods such as gammarid amphipods and rockweed isopods *(Idotea wosnesenskii*) were found within the mussel beds, beneath cobbles, and among the rockweed fronds. Dungeness crab shells and juvenile king crab carcasses were observed at two sites along the eastern shore of Lynn Canal.

Other animals found in tidal pools along the more protected shores within this zone include the burrowing green anemone *(Anthopleura artemisia*), three kinds of limpet *(Lottia strigatella, Tectura persona*, and *T. scutum*), the six-armed sea star *(Leptasterias epichlora*), the crumb-of-bread sponge *(Halichondria panacea*), the green sea urchin *(Stongylocentrotus droebachiensis*), and the dogwinkle snail *(Nucella spp.*).

Lower intertidal – Due to time limitations associated with tidal height, this zone was not directly observed at every location. However, generalizations for organisms can be drawn for similar sites. This zone is often dominated by red algae. On more exposed beaches and on boulders, in particular, there is an almost continuous zone of coralline algae. This algae makes it look as if the rocks had been splashed with pink paint. The red algae *Palmaria hecatensis* and the brown algae *Alaria spp.* often attach on the coralline patches. Filamentous red algae *Polysiphonia spp.* and/or *Pterosiphonia spp.* were also observed at several sites. Sea lettuce was also found in the upper reaches of the lower intertidal zone often in the more protected areas.

Animals found in this zone include the plate limpet *(T. scutum*), crumb-of-bread sponge (in crevices on boulder beaches), and the lined chiton *(Tonicella lineata*). Dense aggregations of green sea urchins and fewer purple sea urchins *(Strongylocentrotus purpuratus*) were also observed in this zone.

Use by EFH species – the sediment beach sites observed during this study ranged from gravel sand beaches in protected cove areas to steep boulder beaches exposed to significant wave actions (see Table 3-7).

Small fish such as crescent gunnels *(Pholis laeta*) and small sculpins were observed in tidal pools at many of the protected sites. Therefore, these more protected sites, consisting of low wave exposure and low angle beaches, could be considered as essential habitat for sculpins, one of the EFH species of considered in this assessment (see Section 4.3). However, the more exposed, steep boulder beaches are less likely to serve as spawning or rearing areas for the EFH species identified in Section 4.3.

4.2.2.2 Bedrock Cliffs and Vertical Rock Faces

As shown on Table 3-7, eight sites are composed entirely of bedrock cliffs and vertical rock faces and exhibit typical intertidal zonation. Many of these sites, and EIT 9 in particular, are indicative of sites that would typically be impacted by sidecasting. All vertical cliff/bedrock sites were observed from the boat. As seen in the photographs taken for these sites (see Attachment A), distinct bands of *Fucus*, *Mytilus*, and *Semibalanus balanoides* and/or *B. glandula* characterize the locations. The brown algae *Alaria spp.* and the sea lettuce *Ulva fenestrata* were observed near the water line as tide levels fell. Many sites also supported the filamentous green algae *Arcosiphonia spp.* and *Cladophora spp*., and coralline red algae. While not observed due to the more remote nature of the survey, it is likely that invertebrates such as gammarid amphipods, littorines, and limpets, as described above for the sediment beach sites, are also present. One of the sites in this group, EIT 16, is located just past the sea lion haulout at Gran Point. Sea lions were observed on site during the survey; in order to avoid disturbing the mammals, the survey was conducted from at least 600 feet offshore.

While these sites likely support prey species for EFH species known to inhabit the project area, their morphology makes it unlikely that they serve as areas important for the spawning, breeding, or growth to maturity for the EFH species.

4.2.2.3 Combinations of Beaches and Bedrock

Eight additional sites visited during the intertidal survey consisted of stretches of rock face or cliff interspersed with cobble/boulder and/or cobble/gravel beaches. Typical zonation patterns as described above were observed, and can be seen in the photographs (Attachment A). The use of these sites by the EFH species depends upon their exposure and percentage of sediment beach versus bedrock cliff (see Table 3-7).

4.2.2.4 Wetlands or Slough/Marsh Areas

One site, EIT 12, is located just south of the potential ferry terminal site near the Katzehin River (see Figures 3-1 and B-3 in Attachment B). EIT 12 is located inland of the large river delta at the mouth of the river, along an old shoreline. Beach pea, sedges, and grasses dominate the site. Other terrestrial plants such as Arctic daisies, bluebells, and mosses were observed. Small western hemlock and Sitka spruce trees edge the old shoreline. The site is not tidally influenced and no tidal pools or potential EFH were observed. The area was mapped for wetlands using aerial photo interpretation and is discussed in the *Wetlands Technical Report*.

4.2.2.5 West Side Fill Locations

Two locations on the west side of Lynn Canal would be impacted by placement of fill for highway construction under Alternative 3. These two sites were not visited during the July 2003 survey, but were evaluated by National Wetlands Inventory (NWI) classification of aerial photos and compared with comparable sites as discussed in detail in the *Wetland Technical Report*. One site, located at Station 4507-3 is situated in the extreme upper intertidal zone and would not be considered used by fish for spawning, rearing, and/or growth to maturity. The other site is upstream of Pyramid Island in a highly depositional zone that also would not be considered highly used as EFH.

4.3 Existing Ferry Terminal Site at Auke Bay

The existing ferry terminals at Auke Bay were not investigated in the 2003 intertidal or subtidal surveys because the habitat of the bay has already been modified. An EFH Assessment completed for the ferry terminal modifications already performed at Auke Bay indicated that the five species of Pacific salmon, flounder, pollock, eulachon, and several species of sole, sculpins pacific cod, and Pacific herring could use the nearshore area of the project site. (DOT&PF, 2003a).

4.4 EFH Species Information

As discussed in Section 1.2, Lynn Canal has been designated as EFH for the following species:

- Pacific salmon: pink *(Oncorhynchus gorbuscha*), chum *(O. keta*), sockeye *(O. nerka*), coho *(O. kisutch*), and Chinook *(O. tshawytscha*)
- Sablefish *(Anoplopoma fimbria*)
- Yelloweye rockfish *(Sebastes ruberrimus)* and other rockfish *Sebastes* species
- Sculpin (family Cottidae)
- Skate (family Rajiidae)
- Pacific herring *(Clupea pallasii*)
- Forage fish (eulachon [*Thaleichthys pacificus*], capelin [*Mallotus villosus*], and sandlance [*Ammodytes hexapterus*])

Although Lynn Canal has not been designated EFH for crab species, they are included in this discussion at the request of OHMP because of their intertidal habitat requirements and human use values within Lynn Canal. The species considered include red king crab *(Paralithodes camtschaticus*), blue king crab *(P. platypus*), bairdi Tanner crab *(Chionoecetes bairdi*), and Dungeness crab *(Cancer magister*).

The following subsections provide a brief discussion of the life history of these species and also provide information (where available) regarding potential habitat for all life stages of these species in Lynn Canal.

4.4.1 Pacific Salmon

Five species of Pacific salmon, pink *(Oncorhynchus gorbuscha)*, chum *(O. keta)*, sockeye *(O. nerka)*, coho *(O. kisutch)*, and Chinook *(O. tshawytscha)*, occur in Alaska. With some important variations, all species have a similar appearance and anadromous life history. Salmon spawn in fresh water and, during the fall, their eggs incubate, hatch, and go through several developmental stages over several months to several years, depending on species. Chinook, coho, and sockeye salmon spend from one to several years rearing in freshwater before migrating to the ocean, whereas chum and pink salmon leave immediately upon emerging from the spawning gravels. The young salmon feed and grow to maturity in saltwater. They return to fresh water, often migrating tremendous distances to reach their natal streams, where they spawn. Adult salmon do not compete directly with juveniles for the food resources found in freshwater environments. Carcasses left in the streams after spawning fertilize the freshwater environment, ultimately providing food for the developing young. No stocks of Pacific salmon originating from freshwater habitat in Alaska are listed under the Endangered Species Act.

Chinook salmon are the largest salmon, often exceeding 30 pounds. Some Chinook salmon outmigrate to the ocean soon after hatching in late winter or early spring (ocean-type), while others remain in fresh water for over one year before outmigrating to the ocean as smolts (stream-type). Fish in any spawning run vary greatly in size; a mature three-year-old will weigh less than 4.5 pounds, while a mature seven-year-old may exceed 50 pounds.

Chum salmon are the second largest of the Pacific salmon. Chum salmon are the most important commercial and subsistence species in Alaska's arctic, northwest, and interior. Chum salmon vary in size from 4.5 to over 29 pounds, but usually range from 6.5 to 18 pounds, with females usually smaller than males. Chum salmon spend little time in fresh water as juveniles. Chum salmon generally return to fresh water to spawn after 3 to 5 years at sea (Johnson *et al.,* 1997).

Pink salmon are the smallest salmon species; adults average 3.5 to 4.5 pounds, with an average length of 20 to 26 inches. In Alaska, adult pink salmon enter spawning streams between June and mid-October. Most pink salmon spawn within a few miles of the coast, and spawning within the intertidal zone or stream termini is very common. In late winter or spring, the fry emerge from the gravel and quickly migrate to the ocean, usually during darkness (Groot and Margolis, 1991). Pink salmon grow rapidly while at sea, with mature fish typically returning to spawning areas after 18 months.

Coho salmon adults average between 8 and 12 pounds, but may reach as much as 30 pounds. Spawning coho enter fresh water from July to November. The fry remain in the gravel, feeding on the yolk sac until they emerge in May or June. Coho spend from one to five years in freshwater streams and lakes before migrating to the sea. The amount of time spent at sea varies greatly, but most coho spend 18 months feeding and growing before returning as full-size adults (Groot and Margolis, 1991).

Sockeye salmon are the most important commercial salmon species in Alaska. Adults average from 4.5 to 8 pounds. After hatching, juvenile sockeye may spend one to four years in fresh water before migrating to the ocean as smolt, weighing only one-fifth of an ounce. Sockeye grow quickly and spend one to four years feeding and growing to maturity in the ocean before returning to spawn (Groot and Margolis, 1991).

The composition of salmon prey species depends on life stage, availability, and relative abundance of prey, which vary with season and location. Chinook salmon feed on small fish (particularly herring), pelagic amphipods, and crab megalopa, with fish being the largest single contributor to their diet (Healey, 1991). Chum salmon diets are composed of amphipod, euphausiid, pteropod, copepod, fish, and squid larvae (Salo, 1991). Pink salmon are opportunistic and generalized feeders and are known to feed on epibenthic harpacticoid copepods, pelagic copepods, barnacle nauplii, mysids, eggs of invertebrates and fishes, and fish larvae (Heard, 1991). Coho salmon are also opportunistic feeders, with diets consisting of marine invertebrates, chum and pink salmon fry, smelts, sandlance, sticklebacks, squid, and crab larvae (Sandercock, 1991). Sockeye are known to feed on euphausiids, amphipods, and small fish (sandlance, herring, pollock, and capelin in the Gulf of Alaska) (Burgner, 1991).

A wide variety of predators including birds, marine mammals, and other species of fish feed on migrant salmon smolts. Predators of large salmon include all toothed whales, seals, sea lions, and shark (Sandercock, 1991).

All five salmon species occur in the project area. Salmon use nearshore migration corridors throughout Lynn Canal to migrate to spawning and rearing grounds in streams that feed into Lynn Canal. Twenty-five streams in the project area (13 on the east side and 12 on the west side of Lynn Canal) have been identified to support anadromous fish populations. These streams are discussed in more detail in the *Anadromous and Resident Fish Streams Technical Report*.

4.4.2 Sablefish

Sablefish *(Anoplopoma fimbria*) are found from northern Mexico to the Gulf of Alaska, westward to the Aleutian Islands, and into the Bering Sea (Wolotira *et al.,* 1993). They are often found in gullies and deep fjords, generally at depths greater than 600 feet. Sablefish observed from a manned submersible were found on or within one meter of the bottom (Krieger, 1997). There appear to be two populations of sablefish: the Alaska population, which inhabits waters near Alaska and northern British Columbia, and the southern or west coast population, which inhabits waters off of southern British Columbia and Washington, Oregon, and California. Mixing of these populations occurs off southwest Vancouver Island and northwest Washington (McDevitt, 1990; Saunders *et al.,* 1996; Kimura *et al.,* 1998). Studies have shown sablefish to be highly migratory for at least part of their life cycle (Heifetz and Fujioka, 1991; Maloney and Heifetz, 1997), and substantial movement between the Bering Sea/Aleutian Islands and the Gulf of Alaska has been documented (Heifetz and Fujioka, 1991). Thus, sablefish in Alaskan waters are assessed as a single stock (Sigler *et al.,* 2001a).

Spawning is pelagic at depths of 900 to 1,500 feet near the edges of the continental slope (McFarlane and Nagata, 1988). Juveniles are pelagic and appear to move into comparatively shallow nearshore areas, where they spend the first one to two years of their life (Rutecki and Varosi, 1997). After their second summer, juveniles begin moving offshore, eventually reaching the upper continental slope and deep-water coastal fjords as adults. Sablefish reach maturity at 4 to 5 years (McFarlane and Beamish, 1990). Sablefish are long-lived, with a maximum recorded age in southeast Alaska inside waters of 88 years (NMFS, 2003).

Larval sablefish feed on a variety of small zooplankton, ranging from copepod nauplii to small amphipods. Both juvenile and adult sablefish are considered opportunistic feeders. Young-of-the-year sablefish are epipelagic and feed primarily on macrozooplankton and micronekton (e.g., euphausiids) (Sigler *et al.,* 2001b). Juveniles that are smaller than 24 inches feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson, 2000), while sablefish that are larger than 24 inches also feed on fish. The most important fish to the sablefish diet include pollock, eulachon, capelin, Pacific herring, Pacific cod, Pacific sandlance, and some flatfish, with pollock being the most predominant at 10 to 26 percent of prey weight, (depending on year). Squid, euphausiids, and jellyfish are also included in the sablefish diet, squid being the most important of the invertebrates (Yang and Nelson, 2000). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the sablefish diet (Laidig *et al.,* 1997), whereas euphausiids dominated the diet for sablefish located off the southwest coast of Vancouver Island (Tanasichuk, 1997).

Adult coho and Chinook salmon feed on juvenile sablefish, the fourth most common reported prey species in the salmon troll logbook program from 1977 to 1984 (Wing, 1985). Pacific halibut also feed on juvenile and adult sablefish, although sablefish make up less than one percent of the stomach contents (NMFS, 2003).

Along with halibut, sablefish are one of the predominant groundfish species in lower Lynn Canal, south of Saint James Bay. Adult sablefish feed in lower Lynn Canal, though the area is on the edge of their more heavily used forage area in Chatham Strait (Bracken, 1990 in USDA Forest Service, 1992). Sablefish spawning occurs primarily in eastern Gulf of Alaska waters (Bracken, 1982), and young sablefish rear in estuarine areas. Sablefish rearing occurs in Lynn Canal estuaries (including Berners Bay and Echo Cove); once the fish mature, they move to deeper water and eventually into the Gulf of Alaska. Older fish return to inside passage waters in the summer to feed (Bracken, 1990 in USDA Forest Service, 1992).

4.4.3 Rockfish

More than 30 rockfish species have been reported to occur in the Gulf of Alaska and Bering Sea (Eschmeyer *et al.,* 1983). Gulf of Alaska rockfish are divided into three ecological categories: demersal shelf, pelagic shelf, and slope. Demersal shelf rockfish are nearshore bottom dwellers, inhabiting the continental shelf in rocky-bottomed areas. There are seven species in this group: yelloweye rockfish *(Sebastes ruberrimus*), quillback rockfish *(S. maliger*), tiger rockfish *(S. nigrocinctus*), china rockfish *(S. nebulosus*), canary rockfish *(S. pinniger*), copper rockfish *(S. caurinus*), and rosethorn rockfish *(S. helvomaculatus*). Pelagic shelf rockfish are nearshore schooling fish, inhabiting the continental shelf in the water column rather than along the ocean floor. There are five species in the pelagic group: black rockfish *(S. melanops*), dusky rockfish *(S. ciliatus*), widow rockfish *(S. entomalus*), yellowtail rockfish *(S. flavidus*), and blue rockfish *(S. mystinus*). Slope rockfish are deepwater species, inhabiting the edge of the continental shelf and continental slope, and include all remaining rockfish species.

Rockfish grow slowly and are long-lived. All rockfish are either ovoviviparous or viviparous (i.e., bear live young after internal fertilization). Most adult rockfish species range in size from 20 to 24 inches long, but can be as small as 5 inches or as large as 41 inches. Some rockfish species can live to ages exceeding 100 years. Some species, such as the yellowtail rockfish, are resident and have a strong preference for a specific site, sometimes returning to their home site when displaced (Carlson *et al.,* 1995; O'Connell, 1991). Parturition typically occurs from February through September, with most species giving birth to larvae in late winter and spring (O'Connell *et al.,* 2002).

Yelloweye rockfish, one of the dominant species in the demersal shelf group in terms of catch and biomass, occur on the continental shelf from northern Baja California to the eastern Bering Sea, commonly at depths less than 200 meters (Kramer and O'Connell, 1988). They inhabit areas of rugged, rocky relief, and adults appear to prefer complex bottoms with the presence of "refuge spaces," whereas juveniles prefer shallow-zone, broken-rock habitat (O'Connell and Carlile, 1993). Yelloweye rockfish become sexually mature at about 20 years of age and have been known to live up to 118 years (Adams, 1980; Gunderson, 1980; Archibald *et al.,* 1981). Yelloweye rockfish give birth over an extended period, with the peak occurring in April and May (O'Connell, 2002). Demersal rockfish have a closed swim bladder, which makes them susceptible to embolism mortality when brought to the surface from depth. Therefore, most species are fatally injured even when caught as discard in other fisheries.

Rockfish diet varies by species. In general, juveniles eat primarily plankton and fish eggs, and adult rockfish feed on crustaceans and fish, such as herring, sandlance, and small rockfish. Yelloweye rockfish are large, predatory fishes that usually feed close to the bottom. Food habit studies indicate that the yelloweye rockfish diet is comprised dominantly of fish, which accounted for 95 percent of the volume in yelloweye rockfish stomach specimens. Herring, sandlance, and Puget Sound rockfish *(S. empheaus*) were particularly dominant. Shrimp are also an important prey item (Rosenthal *et al.,* 1988).

Little information is available regarding rockfish species in Lynn Canal. However, studies have been conducted in the northern portion of southeast Alaska, specifically in areas of southern Lynn Canal and along the coast of Prince of Wales Island, which provide some information about rockfish distribution trends near the project area. During 1971-1972 adult yellowtail rockfish were captured at 40- to 90-foot depths around Point Lena in southern Lynn Canal (Carlson *et al.*, 1995). In 1999, black rockfish were observed at Vanderbilt Reef (just south of Echo Cove) over complex bottoms and vertical wall faces, but no rockfish were seen at Point Bridgett (Johnson et al. 2003). In the southern Lynn Canal and Shelter Island areas, pelagic yellowtail and dusky rockfish were found to be active and feeding at depths from 40 to 90 feet during the months of May through October, while from November to April they moved into crevasses and remained inactive (Carlson and Barr, 1977). Nursery grounds for young rockfish (including yelloweye and yellowtail species) appear to be most abundant along rocky coastal sites between depths of 295 and 325 feet, with diminishing numbers of individuals and diversity in bays and fjords (Carlson and Straty, 1981). Seasonal patterns in rockfish catch near Craig, Alaska (Prince of Wales Island) indicate movement of juvenile (age-1) rockfish to sheltered areas vegetated with eelgrass *(Zostera marina)* and kelp *(Laminaria saccharina)* in April and May, while age-0 rockfish (specifically copper rockfish) move into eelgrass in August and September (Murphy, *et al.* 2000). Rockfish behavior in Craig is relevant to this project because development activities in the area have included filling important fish habitat such as eelgrass beds in intertidal and subtidal zones. U.S. Fish and Wildlife Service (USFWS) divers surveyed the area near the Haines Harbor for a 2002 Environmental Assessment for navigation improvements in Haines and did not document any rockfish species in the area (U.S. Army Corps of Engineers, 2002).

4.4.4 Sculpin

Sculpin are a large, circumboreal family of demersal fishes with habitats ranging from shallow tide pools to depths of 3,000 feet within the North Pacific Ocean and Bering Sea. Sculpin are small, bottom-dwelling fish that lay adhesive eggs in nests, which the males generally guard (Eschemeyer *et al.,* 1983). Most sculpin spawn in winter and lay their eggs against rocks. Larval stage sculpin are found across broad areas of the shelf and slope. Sculpin are often generally found in food-rich habitats, including fast moving, cold water streams; rocky intertidal zones; and piers, wrecks, and reefs.

Life history information varies for each species in this group. Most species grow to 4 to 6 inches, but larger sculpin species can grow several feet in length. The great sculpin *(Myoxocephalus polyacanthocephalus*) is the largest sculpin species, reaching more than 2 feet in length and 17 pounds in weight in the western North Pacific. These species appear to be relatively short-lived with late maturity; the great sculpin does not reach maturity until 5 to 8 years and lives only 13 to 15 years. Many sculpin species, like the Pacific staghorn sculpin *(Leptocottus armatus*), inhabit shallow coastal waters (bay, inlet, sound, or slough) (Eschemeyer *et al.,* 1983). The Pacific staghorn sculpin has a depth range of about 300 feet, can grow 10 to 18 inches in length, and lives approximately 10 years. Pacific staghorn sculpin spawn in winter, and the larvae are planktonic and can be found in estuarine environments (Emmett *et al.*, 1991).

In the Gulf of Alaska, the main prey items for sculpin are small invertebrates (shrimp, crab, barnacles, mussels) and small flatfish. They also feed on eelpouts, other sculpin, and smelt. Sculpin are prey for numerous marine life species, including Steller sea lions, halibut, cod, salmon, hakes/burbots, other sculpin, toothed whales, seals, skate, sablefish, arrowtooth flounder, thornyhead rockfish, pollock, and small flatfish (Gaichas, 2002; 2003). Sculpin larvae eat copepods.

Both the Pacific staghorn sculpin and great sculpin were inventoried by beach seine at the head of Lynn Canal near Skagway during an inventory of marine and estuarine fishes in southeast and central Alaska national parks (Arimitsu *et al.,* 2003). During field surveys conducted for the Juneau Access Improvements Project in 2003, sculpin were identified in tidal pools in the project area.

4.4.5 Skate

Although little specific life history information exists for most skate species, skates are generally thought to have limited reproductive capacity relative to gadids, pleuronectids, and other exploited groundfish (Sosebee, 1998). Skate inhabit inner and outer shelf areas, most commonly soft-bottomed locations, such as muddy bottoms (Allen and Smith, 1988). Skate are similar to shark in that they are long-lived species and have low fecundity and low productivity (Gaichas, 2002). Size varies per species; the big skate, *Raja binoculata*, is the largest skate in the Gulf of Alaska. The California big skate reaches a maximum size of 7.9 feet, and is commonly 6 feet and 200 pounds (Martin and Zorzi, 1993). Big skates have been found in water as shallow as about 10 feet (Martin and Zorzi, 1993), but are most frequently found at 150 to 600 feet (Allen and Smith, 1988). The longnose skate, *Raja rhina*, is smaller, reaching a maximum length of about 4.5 feet in California. Skate probably live to 20 to 30 years of age (Talley, 1983). The maximum age reported for the longnose skate is 13 years; however, there are difficulties associated with determining the age of skates (Zeiner and Wolf, 1993). Longnose skates have been found at depths from 170 to 1,900 feet, but are most frequently found at 300 to 450 feet (Allen and Smith, 1988).

Skate are oviparous, with the eggs fertilized internally and left on the ocean floor to hatch. Embryos are contained in an egg case, a thick, leathery membrane, with one to seven embryos per egg in local species (Eschmeyer *et al.,* 1983).

In the Gulf of Alaska, skate prey mainly on pollock, shrimp, crab, and other benthic epifauna. To a lesser degree, small flatfish, sculpin, eelpouts, smelt, and benthic detritus serve as prey for skate as well. Predators of skate include toothed whales, Steller sea lions, seals, halibut, and Pacific cod.

Skate were collected in trawl surveys performed in the 1970s in Lynn Canal. In a 1976 trawl survey, skates were the second most abundant species after walleye pollock (Parks and Zenger, 1978). As part of the assessment work for the Kensington Mine Project, longlines were set in Berners Bay in October 1988 and April 1989. One skate was captured during each survey (USDA Forest Service, 1992).

4.4.6 Forage Fish

Forage fishes, as a group, occupy a nodal or central position in the North Pacific Ocean food web. Forage fishes are consumed by a wide variety of fish, marine mammals, and seabirds, and many forage species undergo large, seemingly unexplainable fluctuations in abundance. Most of these, such as capelin and sandlance, generally have higher reproductive rates, are shorter-lived, attain sexual maturity at younger ages, and have faster individual growth rates as compared to rockfish and many flatfish, which are generally long-lived, reach sexual maturity at an older age, and grow slowly. Predators that feed on r-selected fish species (marine mammals, birds, and other fish) have evolved in an ecosystem in which fluctuations and changes in relative abundance of these species have occurred. Consequently, most of them, to some degree, are generalists who are not dependent on the availability of a single species to sustain them, but instead rely on a suite of species, any one (or more) of which is likely to be abundant each year. However, differences in energy content exist among forage species, with herring, sandlance, and capelin containing higher energy content per unit mass than other forage species such as juvenile pollock (Payne *et al.,* 1997). Changes in availability of higher energy content forage may influence growth and survival of the upper trophic level species reliant on forage species as their main prey. Important prey species in southeast Alaska include Pacific herring, eulachon (*Thaleichthys pacificus*), capelin (*Mallotus villosus*), and Pacific sandlance *(Ammodytes hexapterus*). Although Pacific herring is not a Federally managed species, adverse impacts on these fish could generate adverse effects on EFH species because Pacific herring are important prey for managed species, and a diminished herring stock could reduce the quality of foraging habitat.

Yang and Nelson (2000) studied the diets of groundfish in the Gulf of Alaska shelf during summer. They found that the main fish prey of groundfish in the Gulf of Alaska included pollock, Pacific herring, capelin, Pacific sandlance, eulachon, Atka mackerel, bathylagids, and myctophids. Although walleye pollock was the most important fish prey of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and walleye pollock in the Gulf of Alaska, other forage fish species comprised 1 to 23 percent of the diet of groundfish. Capelin was important food for arrowtooth flounder and pollock, comprising 23 and 7 percent of the diet, respectively, in 1990. The consumption of capelin by walleye pollock gradually decreased to 3 percent in 1993 and to 0 percent in 1996. Arrowtooth flounder also consumed less capelin in 1993 (4 percent) and in 1996 (10 percent) than in 1990. Eulachon comprised 6 percent of the diet of sablefish. Myctophids were important forage fish for shortraker rockfish, comprising 18 percent of their diet. Pacific sandlance were found in small quantities (1 percent or less) in the stomachs of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and walleye pollock. Bathylagids were found only in the diet of walleye pollock, and they contributed less than one percent.

In the Atlantic, strong interactions between cod and capelin have been recorded (Akenhead *et al.*, 1982). Even though Pacific cod did not feed as heavily on capelin in the Gulf of Alaska, capelin was an important fish prey of several groundfish species. The distribution and abundance of forage fish in the Gulf of Alaska are not well known. However, a series of years with poor forage fish recruitment, which decreases the availability of small prey fish, may have a large impact on piscivorus groundfishes.

Herring, eulachon, capelin, and sandlance are all important forage species in the Lynn Canal area. Eulachon are particularly abundant in Berners Bay, where estuarine wetlands support eulachon and other smelts that spawn in the Lace, Berners and Antler rivers. In samples collected in Auke Bay from mid-March through mid-June 1986 to 1989, the dominant larval fish were walleye pollock, flathead sole, eulachon, Pacific sandlance, and rock sole (Haldorson *et al.*, 1990). In larval samples collected in Berners Bay in 1972, walleye pollock and smelt species *(Osmerididae* and *Bathylagidae*) were abundant, particularly in May and June (Mattson and Wing, 1978). Capelin are also known to spawn in Berners Bay, though their numbers are relatively small and knowledge of their activity in the area is limited (Ingledu, 1990 in USDA Forest Service, 1992). Humpback whales, peregrine falcons, bald eagles, Steller sea lions, and harbor seals feed on eulachon in Berners Bay.

4.4.6.1 Pacific Herring

General Life History and Ecology – Details concerning Pacific herring life history and occurrence in Lynn Canal are provided in Attachment C. The following section provides a summary of information in the attachment. Pacific herring *(Clupea pallasii)* occur from California, north to the Gulf of Alaska and Bering Sea, to Japan. They spend much of their lives in nearshore waters (Carlson, 1980; Hay, 1985). Pacific herring may grow to a length of 18 inches and weigh over one pound, but average nine inches long and about 0.5 pounds. The average life span for herring is about 8 years in southeastern Alaska.

There are migratory and non-migratory stocks of Pacific herring. Lynn Canal supports stocks of non-migratory resident herring that overwinter in coastal bays and inlets, and then move to adjacent sites to spawn (see Attachment C). In southeastern Alaska, schools of Pacific herring begin spawning in mid-March. The timing of spawning is related to water temperatures (North Pacific Fishery Management Council [NPFMC], 1999). Spawning occurs in shallow, vegetated, intertidal and subtidal areas, possibly as an adaptation to minimize egg loss (Emmet *et al.,* 1991; Haegele and Schweigert, 1985). Specifically, Pacific herring spawn in Berners Bay and Auke Bay in April and May, depositing spawn on eelgrass, pilings, and other substrate up to 10 feet above MLLW (Craig Ferrington, ADF&G, personal communication in SWCA Environmental Consultants, 2002). Primary spawning areas in Lynn Canal are along the south side of Berners Bay and south along the east shore of Lynn Canal, occasionally along the east shore of Lynn Canal 1 to 2 miles north of Berners Bay, and near the head of Lynn Canal on the west side of the Chilkoot Inlet. In 1996, herring spawn was observed on kelp approximately 200 yards north of Cascade Point, continuing north past Sawmill Creek (MacGregor, 1996 in USDA Forest Service, 1998). It is important to note that the marine intertidal area adjacent to the alignment in the areas of Berners Bay mentioned above provides spawning habitat considered critical by OHMP, NMFS, and USFWS for the stock's viability (not an official designation).

Pacific herring eggs are adhesive, and survival is greater for those eggs that stick to vegetation than for those that fall to the bottom. However, if spawn is deposited on vegetation, Haegele and Schweigert report "they do not appear to favor one vegetation type over another" (1985). Others, however, have observed that herring prefer to spawn on courser vegetation given a choice (Stacey and Hourston, 1982; Aneer, 1983 in Aneer, 1985). Whatever the substrate used, it is generally agreed that spawn is deposited on substrates "free from sediments," as silting may disrupt the spawning sequence (Stacey and Hourston, 1982; Lassuy, 1989). Herring are annual spawners upon reaching maturity and spawn in the same general locations every year (Emmet *et al.,* 1991; Lassuy, 1989). Herring spawn every year after reaching sexual maturity at 3 or 4 years of age.

Milt released by the males drifts among the eggs, fertilizing them. A spawning event is usually completed within one to three days, with larger fish in the stock spawning before smaller fish, (Hay, 1985), and each subsequent event is separated from the previous one by approximately one to several weeks. The eggs hatch in about two weeks, depending on water temperature. Stress during egg stage can result in malformation or incomplete development of larvae, which can impair survival (ADF&G, 1985). The young larvae drift and swim with the ocean currents. According to Hourston and Haegele (1980), the larval stage is most vulnerable, with mortalities as high as 99 percent (1980). Copepods, invertebrate eggs, and diatoms comprise the majority diet of early feeding larvae (Hart, 1973).

Two to three months after hatching, larvae metamorphose to juvenile form upon reaching a fork length of about 26 mm. At lengths of 25 to 40 mm, juveniles begin to school and usually remain in inshore waters during the first summer (Hay, 1985). Because limited winter feeding is insufficient for metabolic demands, young-of-the-year juveniles are required to gain sufficient energy stores during summer to successfully overwinter (Foy and Paul, 1999). Summer conditions bring a seasonal peak in total zooplankton, and it has been shown that juvenile herring depend on both pelagic and benthic food webs in shallow bays, inlets, and fjords in summer and early fall. Diet studies for juvenile herring in Prince William Sound found that barnacle nauplii, large and small copepods, fish eggs, larvaceans, juvenile euphausiids, and mysids were the dominant prey items (Norcross *et al.*, 2001). First and second year juveniles may school offshore, remaining separated from schooling adults until reaching maturity, generally within two to five years.

After spawning, most adults leave inshore waters and move offshore to feed. They are seasonal feeders and accumulate fat reserves for periods of relative inactivity. Herring schools often follow a diel vertical migration pattern, spending daylight hours near the bottom and moving upward during the evening to feed (Hart, 1973). Adult Pacific herring feed on zooplankton, pollock larvae, sandlance, capelin, and smelt (Schweigert *et al.,* 1997). Herring eggs and young larvae are preyed upon extensively by other vertebrate and invertebrate predators, including salmon, Steller sea lions, seals, seabirds, and whales (USDA Forest Service, 1992). Juvenile and adult herring are also important prey for other fish, marine mammals, and seabirds.

Lynn Canal Stock Status and Trends – Stocks near Sitka, Craig, and Auke Bay were first differentiated in the 1930s using spawning and feeding locales, vertebral counts, growth rates, and tagging studies (Rounsefell and Dahlgren, 1935 in Carlson, 1980). By the 1970s, five major stocks or populations were identifiable by their concentration on wintering grounds: 1) Sitka, 2) Auke Bay, 3) Craig-Hydaburg, 4) Deer Island (Etolin Island near Wrangell) and 5) Ketchikan. Biomass estimates in each locale consistently exceeded 2.27 million kilograms (i.e., approximately 2,500 tons, the minimum level to be classified as a major stock) in each locale during the winters of 1971 to 1979 (Carlson, 1980).

At least 14 major herring stocks, differentiated by spawning area, are currently managed for commercial harvest in southeast Alaska under minimum spawning threshold levels (Hebert and Pritchett, 2002). Stocks with a spawning biomass of less than 2,000 tons are not considered for harvesting in either the southeast Alaska winter bait or sac roe fisheries. In general, the stocks that spawn on the outer coastal areas are more productive than stocks that spawn in inside waters (Hebert and Pritchett, 2002).

Herring that winter in Auke Bay and Fritz Cove apparently constitute most of the stock of fish that spawn in Lynn Canal (Carlson, 1980). The Lynn Canal stock is one of the least migratory stocks in southeast Alaska (personal communication, Kevin Monagle, ADF&G). Tagging studies have shown that the Lynn Canal (Auke Bay) stock has a distinct summer feeding area and does not intermingle with other stocks, unlike the outer coast Sitka and Craig stocks, which migrate and intermingle in summer feeding areas (Carlson, 1980).

Historically there have been two direct observation methods for estimating biomass of herring stocks in southeast Alaska: 1) post-spawning egg deposition dive surveys, and 2) vessel hydroacoustic surveys (Hebert and Pritchett, 2002). However, beginning in 1994 ADF&G modified the primary method of forecasting herring abundance for major spawning stocks to age structured analysis (ASA), which relies on time series of herring population structure data collected in the field. ASA is currently used to forecast herring biomass for those stocks with adequate historical data (Revillagigedo Channel, Sitka, Craig, Tenakee Inlet, and Seymour Canal).

The herring spawning threshold level for the Lynn Canal fishery is currently 5,000 tons (10 million pounds). This threshold value was increased from 4,000 tons in 1983 based upon a reevaluation of historical herring spawning population levels and the failure of the Lynn Canal stock to increase in size under the previous threshold level. The Lynn Canal herring biomass threshold was originally set based on acoustic estimates (from 1971-72 through 1981-82 seasons), linear miles of shore receiving spawn 20 years (from 1953 through 1982), and dive surveys (1978, 1980, 1983).

Prior to 1980, the adult spawning biomass of Lynn Canal herring stocks was consistently above 4,000 tons and supported several commercial fisheries, including a sac roe fishery, bait pound fishery, and a winter food and bait fishery (Figure 3). By 1982, the stock was showing a decline in biomass and has since remained at low levels. Current estimates by ADF&G suggest that the population of mature adult fish has fallen to near 1,000 tons. The 1,000-ton estimate has been corroborated by hydroacoustic surveys of over-wintering populations of adult herring in the Juneau area (personal communication, Mike Sigler, NMFS 2004). Various hypotheses have been made about why the stock has declined, although none have been substantiated by scientific analysis. The hypotheses inclue one or a combination of the following factors: overfishing, increased predator populations, disease, habitat alteration/degradation, water pollution, and unfavorable oceanographic conditions. Because the herring stock in Lynn Canal is depressed, the stock is subject to increased vulnerability from impacts associated with any of these factors. For instance, the increasing Steller sea lion population in Lynn Canal could be applying increased predation pressure to the stock.

The linear extent (miles) of Lynn Canal shoreline with documented herring spawn (a factor used to estimate adult biomass) has similarly declined since the 1970s (Figure 3). The documented spawn for the Lynn Canal herring stock from 1953 to 1981 ranged from 6 to 28 nautical miles, and averaged approximately 12 miles. Since 1982 the documented spawn has ranged from 0.5 to 7 nautical miles, averaging less than 4 nautical miles. In the spring of 2003, only 3 miles of herring spawn were observed in all of Lynn Canal.

Spawning location in Lynn Canal has also changed considerably over the past few decades times (see Attachment C). Lynn Canal herring traditionally spawned from Auke Bay to Point Sherman, including Berners Bay. In recent years, however, there has been very limited spawning in Auke Bay, with spawning activity for the entire Lynn Canal herring stock now centered between Point Bridget and the Berners Bay flats.

Commercial Harvest – Total annual Lynn Canal herring harvest averaged less than 1,000 tons from 1959 to 1981-82, before fishing was stopped in 1982-83 (see Attachment C). Up through the early 1970s, much of the harvest was taken by pound net at Indian Cove to provide bait for the commercial long-line, pot, and recreational fisheries. Purse seine and gillnet fisheries targeting herring for sac roe then superseded the bait fishery in the 1972-73 season, and continued to harvest the bulk of adult herring until the fishery was closed in 1982-83, when biomass fell below the 4,000-ton spawning threshold. As previously noted, the herring spawning threshold level for the Lynn Canal fishery was increased to 5,000 tons in 1983 based on the failure of the Lynn Canal stock to increase in size under the previous level. It is currently unclear from the records why harvest occurred in the 1972-73 and 1981-82 seasons when spawning biomass thresholds were not met.

4.4.6.2 Eulachon

General Life History and Ecology – Eulachon are an anadromous, short-lived member of the Osmerididae family (smelts). They are the largest of the North American Pacific Coast smelts (see Attachment C for additional details). Within their range, eulachon spawn regularly in only 30 to 40 major rivers (Department of Fisheries and Oceans, 1999). Most of the streams that support eulachon migration are mainland, glacier-fed systems. Southeast Alaska has more than 25 streams that support runs of eulachon. In southeast Alaska, spawning begins as early as

April when eulachon gather in large schools off the mouths of their spawning rivers. Spawning occurs in the lower reaches of rivers with moderate velocities at ambient temperatures of 3 to 10ºC (Department of Fisheries and Oceans,1999). Upstream migration is closely linked to the spawning river water temperature. Temperatures below 4ºC may retard adult migrations (Emmett *et al.,* 1991). Eulachon mass spawn at night without building nests. Hay and McCarter suggest that if eulachon home to natal rivers, imprinting during egg and early larval stage in freshwater is improbable due to the shortness of these stages and the lack of necessary physiological tissue (2000). Therefore, imprinting is more likely specific only to estuarine waters rather than to specific rivers, either within estuaries (e.g., Berners Bay) or tributaries to large river systems (e.g., Fraser River).

Eulachon eggs hatch within 3 to 5 weeks. Newly hatched larvae are 4 to 7 mm and river currents quickly flush the larvae to marine waters, where they may be retained in low-salinity, estuarine surface waters for several weeks or more (Hay and McCarter, 2000). Larvae are planktivorous and feed primarily on phytoplankton, copepods, ostracods, cladocerans, mysids, and larvae of various species, including their own (Emmet *et al.*, 1991). Metamorphosis to the juvenile stage occurs at lengths of about 30 to 35 mm.

The distribution and ecology of juvenile and pre-spawning adult eulachon are not well known. Juveniles appear to live in near-benthic habitats in depths of approximately 20 to 150 meters during their first 2 to 3 years (Hay and McCarter, 2000). Adults are found in the marine neritic zone at various depths until the sexually mature segregate from the rest of the population to migrate to spawning rivers. Juveniles and adults feed primarily on euphausiids, copepods, and other planktonic crustaceans (Emmet *et al.*, 1991).

Eulachon can live to age 5 and grow to 10 inches, but most die following their first spawning at age 3. Eulachon are an important food source for humans and an important prey species for fish and marine mammals, such as salmon and the Steller sea lion. Upstream migration is closely keyed to the water temperature of the stream; in southeast Alaska, migration can occur as early as April. The abundance of eulachon throughout their range appears to have been decreasing since the early 1980s.

Lynn Canal Stock Status and Trends – The ADF&G has no formal stock assessment projects for eulachon in southeast Alaska. To the best of our knowledge, no historic quantitative assessments of eulachon biomass or run strength have been conducted in any of the Lynn Canal river systems. Because quantitative assessments are lacking, the status of Lynn Canal eulachon stocks is primarily based on anecdotal evidence or trends from other regions (see Attachment C). Genetic analyses indicate that eulachon populations throughout their entire geographic range constitute a single evolutionarily significant unit (McLean and Taylor, 2001), thereby suggesting that population trends conducted in other regions may have some applicability to Lynn Canal stocks. In a status review of eulachon in Canada, Hay and McCarter point out that almost all spawning runs of eulachon from California to southeast Alaska have declined over the last 20 years, particularly since the mid 1990s. (2000)

Subsistence and Personal Use Harvest – Eulachon are primarily harvested for subsistence or personal use in the Lynn Canal region. Because much of this harvest is sustainable, there has been little need for intensive management of the fishery. More recently, however, a number of factors (proposed development projects, perceived population declines, and federal listing of Steller sea lions) have led to some efforts at establishing some baseline index streams for population monitoring. Thirty-three spawning runs have been documented for southeast Alaska (see Attachment C). Of these, the importance of the Chilkat and Chilkoot rivers to subsistence harvest (customary & traditional use) has been well documented (Betts, 1994; personal communication, M. Turek, ADF&G). Eulachon are harvested in the intertidal waters at the river mouths during the late winter to early spring when the runs are strong and the fish appear in large numbers. In practice, this fishery is regulated by local rules developed by traditional harvesters rather than by external State or Federal regulations (Betts, 1994). Traditional use of runs in Berners Bay is also thought to have occurred, but is less well documented and currently is in the State of Alaska's Juneau non-subsistence use area (personal communication, M. Turek, ADF&G). Eulachon may be taken in Berners Bay at any time under personal use fishing regulations, and there are no bag or possession limits.

4.4.6.3 Capelin

Capelin are distributed along the entire coastline of Alaska and south along British Columbia to the Strait of Juan de Fuca. In the North Pacific Ocean, capelin can grow to a maximum of 10 inches at age 4. Most capelin spawn when they are between 4 and 7 inches at age 2 or 3 (Pahlke, 1985). Spawning occurs in spring in intertidal zones of coarse sand and fine gravel, especially in Norton Sound, northern Bristol Bay, and around Kodiak Island. Very few capelin survive spawning.

The diet of capelin in the North Pacific Ocean is primarily planktivorous (Hart, 1973; Trumble, 1973). Small crustaceans such as euphausiids and copepods are common to the diet of capelin, although marine worms and small fish are also part of their diet. The largest capelin consume euphausiids almost exclusively. Capelin diets exhibit seasonal variation due in part to spawning migration and behavior.

4.4.6.4 Pacific Sandlance

Pacific sandlance are usually found on the sea bottom, from the surface down to 300 feet, except when feeding. Pacific sandlance feed in the water column on crustaceans and zooplankton. The abundance and distribution of sandlance is not well known; trawls rarely catch them. In the Gulf of Alaska, sandlance are prey of harbor seals, northern fur seals, and marine birds, especially in the Kodiak Island area and along the southern peninsula. Given the sandlance's short life span and the large number of species that prey upon the sandlance, mortality, fecundity, and growth rates are probably high. Sandlance spawn in the late fall and winter. Larvae hatch over an extended period, usually until March (Blackburn *et al.*, 1983; Blackburn and Anderson, 1997). Newly hatched larval and adult sandlance migrate offshore in early spring, and return inshore to coastal habitat to spawn and overwinter in the late summer. Inshore migrating schools of sandlance provide important forage for migrating seabirds during the late summer and early fall. Sandlance are among the few fish species that overwinter at inshore areas and migrate offshore in the summer.

The diet of sandlance in the North Pacific Ocean is primarily planktivorous. Larval sandlance consume diatoms and dinoflagellates; post-larvae prey upon copepods and copepod nauplii. Age-0 and age-1 sandlance also show a dominance of calanoid copepods in the diet, with barnacle nauplii, larvaceans, and shrimp larvae as other important prey (Blackburn and Anderson, 1997). Adult sandlance prey upon chaetognaths, fish larvae, amphipods, annelids, and common copepods. Sandlance exhibit seasonal and diurnal variation in feeding activity and are opportunistic feeders upon abundant plankton blooms.

4.4.7 Crab

The commercially important crab species in southeast Alaska, particularly in Lynn Canal, are red king crab (Paralithodes camtschaticus), blue king crab (P. platypus), golden king crab (Lithoides aequispinus), bairdi Tanner crab (Chionoecetes bairdi), and Dungeness crab (Cancer magister). King and Tanner crab share a similar life cycle, although particular life cycle traits are distinct for each species. Each life stage of crab stocks is concentrated at some combination of depth, habitat, geographic area, and time of year. Red and blue king, bairdi Tanner, and Dungeness crabs are all found at depths between the intertidal zone and about 600 feet (depending on their life stage), whereas golden king crabs are usually found much deeper, usually between 600 to 1,600 feet (ADF&G, 2004). Because golden king crabs are found at depths greater than where the potential project impacts are expected to occur, they are not considered in this report.

Crabs are benthic organisms and therefore depend on specific habitat types throughout their life stages. Settlement on habitat with adequate shelter, food, and temperature is imperative to the survival of first settling crab. Young-of-the-year red and blue king crab require nearshore shallow habitat with significant protective cover (e.g., sea stars, anemones, microalgae, shell hash, cobble, shale) (Stevens and Kittaka, 1998). Early juvenile stage bairdi Tanner crab also occupy shallow waters and are found on mud habitat (Tyler and Kruse, 1997). Juvenile Dungeness crabs prefer mud and sand substrate (ADF&G, 2004). The following sections describe specific life history traits, potential occurrence in the project area, and commercial/subsistence/personal use harvest in Lynn Canal for each species identified above.

4.4.7.1 Red King Crab

General Life History and Ecology – Red king crab (*Paralithoides camtschaticus*) are generally found from the intertidal zone to 600 feet (ADF&G, 2004). Adult red king crabs exhibit annual migrations, traveling from nearshore to offshore (or shallow to deep) and back. They move to shallow water in late winter, and by spring the female's embryos are ready to hatch. Adult females and some adult males molt and mate before they start their offshore feeding migration to deeper waters.

Red king crab mate when they enter shallower waters (less than 150 feet), usually between the months of January and June. Prior to the female molting, the male crabs grasp the females, fertilizing between 43,000 and 500,000 eggs, which are then extruded on the female's abdomen. The females carry the eggs externally for 11 months before they hatch, which generally occurs in April. Red king crabs spend between two to three months in larval stages before they settle into the benthic life stage. Young-of-the year crab are found at depths less than 150 feet They are solitary and require high-relief habitat or coarse substrate, such as boulders, cobble, shell hash, and living substrates, such as bryozoans and stalked ascidians for cover (Stevens and Kittaka, 1998). Around 1.5 to 2 years, the late juvenile crabs form pods that can consist of thousands of crab. As the crabs grow, they migrate to deeper water.

In the trophic structure, crabs are members of the inshore benthic infauna consumers guild (NMFS, 2003). During each life stage, crabs consume different prey and are consumed by different predators. Planktonic larval crabs consume phytoplankton and zooplankton. Post settlement juveniles feed on diatoms, protozoa, hydroids, crab, and other benthic organisms.

Food eaten by king crab varies with size, depth inhabited, and species, but includes a wide assortment of worms, clams, mussels, snails, brittle stars, sea stars, sea urchins, sand dollars, barnacles, fish parts, and algae.

Planktonic larval crab are prey for pelagic fish, such as pollock, salmon, and herring. Adult king crab fall prey to a wide variety of species including Pacific cod, Pacific halibut (Alaska plaice, yellowfin sole, flathead sole), arrowtooth flounder, octopus, and large king crab (Livingston *et al.*, 1993).

Lynn Canal Stock Status and Trends – The southeast red king crab fishery is one of the few southeast shellfish fisheries that has a history of yearly stock assessments and a well-developed management plan (ADF&G, 2002a). ADF&G's 2001-02 season stock assessment results indicated a biomass of just less than 1 million pounds of male red king crabs in the northern portion of southeast Alaska (in bays opening into Icy Straight, Lynn Canal, and upper Stephens Passage) (ADF&G 2002b).

In addition to stock assessments, population concentrations of red king crabs can be inferred from historical harvest information collected by ADF&G. Cumulative commercial shellfish catch during the seasons 1993-94 to 2002-03 in the various subdistricts of Lynn Canal (District 15) has been summarized by G. Bishop (ADF&G, personal communication, April 8, 2003). The largest portion of the commercial harvest of red king crab has occurred in the area from the entrance of Lynn Canal north to Point Sherman and totaled just over 62,000 pounds, accounting for approximately 75 percent of the total district harvest of about 83,000 pounds. The second largest fraction of commercial harvest has occurred in the mid-Lynn Canal area, between Point Sherman and the southern tip of the Chilkat Peninsula, and totaled approximately 12,500 pounds, or 15 percent of the total district harvest.

Commercial, Subsistence, and Personal Use Harvest – Red king crabs are harvested primarily in the protected bays, inlets, and adjacent shorelines of straits and sounds in southeast Alaska north of Petersburg, including Lynn Canal. Documentation of commercial king crab fisheries in southeast Alaska waters began in 1960. In January 1984, the Commercial Fisheries Entry Commission (CFEC) established a limited entry program for the king crab pot fishery in southeast Alaska (ADF&G, 2002). The CFEC implemented a maximum effort level of 61 permits for the fishery. As of 2002 there were 81 permits eligible to participate in the Registration Area A fishery. During the 2001-02 season, 15,500 pounds of red king crab were harvested in District 15, accounting for 5.2 percent of the total harvested in Registration Area A (297,000 pounds) (ADF&G, 2002b).

Personal use king crab fisheries occur in Lynn Canal with harvest effort concentrated primarily near William Henry Bay and the Sullivan Island area, in addition to Berners Bay. Sport fish catch information from ADF&G combines *Paralithoides* species into one category, so species-specific information is not available for red and blue king crabs. Data from ADF&G's Sport Fish Harvest Survey indicates that 147 individual king crabs were harvested throughout Lynn Canal during the 2001 season (see the *Land Use and Coastal Management Technical Report*). In upper Lynn Canal, king crabs are harvested for subsistence purposes in the waters of the following areas: Taiya Inlet, Flat Bay, Chilkat Inlet, the west side of Sullivan Island, and between Sullivan and the Chilkat islands to the entrance of Chilkat Inlet (see the *Land Use and Coastal Management Technical Report*).

4.4.7.2 Blue King Crab

General Life History and Ecology – Blue king crabs (*P. platypus*) have an intermittent distribution throughout southeastern Alaska to Japan and usually form distinct populations along rocky coasts, rocky islands, and fjord-like areas. Adult male blue king crabs occur at an average depth of 200 feet and an average water temperature of 33°F. Blue king crab molt multiple times during their juvenile phase. Skip molting occurs with increasing probability for males larger than 4-inch carapace length. Blue king crabs have a biennial ovarian cycle and a 14-month embryonic period before hatching in late spring. Juveniles require cobble habitat with shell hash. Unlike red king crab, juvenile blue king crabs are solitary and rely on camouflage for protection from predators. General information regarding king crab trophic interactions is provided in the red king crab section (see Section 4.3.7.1).

Lynn Canal Stock Status and Trends – In Registration Area A, the blue king crab population has dropped to historic low levels, as is shown in the comparisons of recent catches to the peak 1982-83 season. Preliminary numbers show that only 880 pounds of blue king crab were harvested in 2001-02, compared to over 46,000 pounds of blue king crab landed during the 1982-83 season (ADF&G, 2002b). There are no data specifically for the Lynn Canal blue king crab stocks, because the focus of king crab stock assessments is on the commercially important red king crab.

Commercial, Subsistence, and Personal Use Harvest – There is no stand-alone blue king crab fishery, just the openings associated with the concurrent red king and bairdi Tanner crab fisheries, during which small quantities of blue king crab are commercially harvested (ADF&G, 2002a).

4.4.7.3 Dungeness Crab

General Life History and Ecology – Dungeness crabs (*Cancer magister*) are members of the highly evolved brachyuran (true crab) subgroup of the order Crustacea that inhabit bays, estuaries, and the nearshore coast of Alaska. Their preferred habitat consists of mud or sandy bottom and eelgrass beds, subtidally from low intertidal to approximately 600 feet, where they are frequently buried during daylight hours (Alaska Fisheries Science Center 2004). However, they are tolerant of salinity changes and can be found in estuarine environments (e.g., Berners Bay). Dungeness crabs are widely distributed and can be found as far north as Cook Inlet and Prince William Sound, Alaska, and as far south as Magdalena Bay, Mexico. This crab supports both a commercial fishery and a personal use fishery in Alaska.

Dungeness crabs mate from spring through fall, and the male crabs are polygamous, so each male crab may mate with more than one female crab. Polygamy may play an important role in maintaining the reproductive viability of this species because harvest in commercial and personal use fisheries is limited to male crabs. Male crabs mate only with female crabs that have just molted (shed their old exoskeleton). Unlike other species, fertilization of the eggs does not occur at the time of mating. Instead, the female crab stores the sperm until her eggs are fully developed, upon which time she extrudes the eggs under her abdomen, fertilizes them, and carries them there until hatching. A large female crab can carry 2.5 million eggs (ADF&G, 2004).

After hatching, the young crabs are planktonic and swim freely. In the colder waters of Alaska, the duration of larval development is between four months to a year. Larval crabs pass through six successive stages (five zoea and one megalopa) before they molt into the first juvenile stage. The crabs grow each time they molt. During the first two years both sexes grow at comparable rates, but after two years the growth rate for males surpasses that of females. Sexual maturity can be reached at three years for both sexes. At four to five years of age, a Dungeness crab can be over 6.5 inches in shell width and weigh between 2 and 3 pounds. The shell of a large male Dungeness crab can exceed 10 inches in width. The estimated maximum life span of these crabs is between eight and 13 years (ADF&G, 2004).

The foraging area of Dungeness crabs overlaps their habitat. These crabs scavenge along the sea floor for organisms that occur either partially or completely buried in the sand. Dungeness crabs are carnivores, and their diet includes shrimp, mussels, small crabs, clams, and worms.

Lynn Canal Stock Status and Trends – ADF&G conducts two types of pre-season stock assessments to allow prediction of stock strength for the upcoming season: port sampling and pot surveys. Since 1985, commercial Dungeness crab landings in southeast Alaska have been sampled in various ports, such as Haines. Since 2000, Dungeness crab pot surveys have included Berners Bay. Information from these surveys for Lynn Canal is minimal, as the focus tends to be in other areas of southeast, such as Duncan Canal and Stikine Flats (ADF&G, 2002c).

In lieu of stock assessment data, population concentrations of Dungeness crabs can be inferred from historical harvest information collected by ADF&G. Cumulative commercial shellfish catch during the seasons 1993-94 to 2002-03 in the various subdistricts of Lynn Canal (District 15) has been summarized by G. Bishop (ADF&G, personal communication, April 8, 2003). The largest portion of the commercial harvest of Dungeness crab has occurred in the area from the entrance of Lynn Canal north to Point Sherman, and totaled just over 102,000 pounds, accounting for approximately 30 percent of the total District 15 harvest of about 340,000 pounds. The second and third largest volume harvests have occurred in the mid-Lynn Canal area, between Point Sherman and the southern tip of the Chilkat Peninsula, and in Berners Bay, respectively. These harvests totaled approximately 94,000 and 68,000 pounds, or 28 percent and 20 percent of the total District 15 harvest, respectively.

Commercial, Subsistence, and Personal Use Harvest – Southeast Alaska (Registration Area A) is a super exclusive registration area for Dungeness crab, meaning that a vessel registered to fish in Registration Area A cannot register in any other area in Alaska during the same registration year. The fishery is also under limited permit entry. Although there are 319 current (2003) Dungeness crab limited entry permit holders, actual participation is variable. During the past five seasons (1998-99 to 2002-03), an average of 216 permit holders have registered and fished in southeast Alaska (ADF&G, 2002c). Two commercial Dungeness crab fishing seasons exist in northern southeast Alaska (includes Lynn Canal): a summer season (June 15 to August 15) and a fall/winter season (October 1 to November 30). Since 1960, when harvest statistics were first separated out by year, the average commercial Dungeness crab harvest from southeast Alaska has been 2.2 million pounds per season (ADF&G, 2002c).

The Dungeness crab fishery generally occurs in the shallower waters of bays and inlets. In Lynn Canal these areas include Berners Bay, the south Chilkat Islands, Mud Bay, the Katzehin River area, the shoreline from Battery Point to Lutak Inlet, the east and west sides of Chilkat Inlet north and south of Pyramid Harbor, and adjacent to Glacier Point. Commercial harvests of Dungeness crab in Lynn Canal have averaged about 78,000 pounds since 1993 (Source: *Land Use and Coastal Management Technical Report*).

The 2001-02 commercial harvest of Dungeness crabs in District 15 was nearly 37,000 pounds, less than 1.0 percent of the total harvest in Registration Area A of 4.1 million pounds (ADF&G, 2002c). Preliminary information for the 2002-03 season indicates that approximately 5.9 million pounds of Dungeness were harvested in Registration Area A (ADF&G, 2002c).

Residents of Alaska may harvest Dungeness crabs for personal use. However, this fishery is often secondary to recreational boat outings. Crab pots similar to those used in the commercial fishery, ring nets, diving gear, dip nets, and hooked or hookless handlines, can all be used to harvest crab for personal use. Personal use anglers generally fish at depths between 18 and 120 feet where more “keepers,” male crabs greater than 6.5 inches wide, are usually found (ADF&G, 2004). Data from ADF&G’s Sport Fish Harvest Survey indicates that 1,401 individual Dungeness crabs were sport-harvested throughout Lynn Canal during the 2001 season (see the *Land Use and Coastal Management Technical Report*). Subsistence harvest of Dungeness crab occurs in the following areas of upper Lynn Canal: Lutak Inlet, Chilkoot Inlet, Chilkat Islands, Glacier Point, Mud Bay, St. James Bay, coves of Sullivan Island, and Letnikof and Paradise coves.

4.4.7.4 Bairdi Tanner Crab

General Life History and Ecology – Tanner crabs, (*Chionoecetes bairdi* and *C. opilio*) are two of the four brachyuran (true) crab species of the genus *Chionoecetes* found in the temperate and subarctic waters of the western Pacific Ocean from northern California to the Bering Sea. Only *C. bairdi* is known to be present in the Lynn Canal area. After many molting cycles as juveniles, bairdi Tanner crab reach sexual maturity at six years old. Carapace widths average 4 to 4.5 inches for males and 3 to 4 inches for females (Tyler and Kruse, 1997). After reaching maturity, females undergo one terminal molt. Molting frequency for males decreases after maturity; however, a terminal molt for males has not been determined (Zheng *et al.*, 1998). Male bairdi Tanner crab reach a maximum size of 7.5 inches carapace width and have a maximum age of at least 15 years (Donaldson *et al.*, 1981). Males of commercial size may range between 9 and 11 years old and vary in weight from approximately 2.5 to 5 pounds (Adams, 1979). Female bairdi Tanner crabs are known to form high-density mating aggregations, or pods, consisting of hundreds of crab per mound. It is thought that these mounds may provide protection from predators and attract males for mating. Research indicates that female bairdi Tanner crab prefer to mate with large, old-shell males (Paul and Paul, 1996; Paul *et al.*, 1995). Mating occurs from January through June, after which time some females can retain viable sperm in spermathecae for up to two years. Females carry clutches of 50,000 to 400,000 eggs for one year after fertilization. Eggs hatch between April and June (Tyler and Kruse, 1997). Spawning habitat for bairdi Tanner crab in the Lynn Canal has/has not been identified.

Trophic interactions for tanner crabs are similar to those discussed generally for red king crabs (see Section 4.3.7.1). Specifically bairdi Tanner crab are consumed by a wide variety of predators including groundfish, walrus, bearded seals, sea otters, octopus, Pacific cod, Pacific halibut and other flatfish, eelpouts, sculpins, and adult tanner crab (Tyler and Kruse, 1997).

Lynn Canal Stock Status and Trends – According to ADF&G (2002d), there are currently no bairdi Tanner crab stock assessments performed in Lynn Canal (District 15). As of the 2001-02 season, ADF&G considered the current stock status of bairdi Tanner crabs in southeast Alaska (the entire Registration Area A) to be poor, with catches on the decline over the past four seasons (ADF&G, 2002d).

In lieu of stock assessments, population concentrations of bairdi Tanner crabs can be inferred from historical harvest information collected by ADF&G. Cumulative commercial shellfish catch during the seasons 1993-94 to 2002-03 in the various subdistricts of Lynn Canal (District 15) has been summarized by G. Bishop (ADF&G, personal communication, April 8, 2003). The largest portion of commercial harvest of bairdi Tanner crab has occurred in the area from the entrance of Lynn Canal north to Point Sherman and totaled just over 194,000 pounds, which is approximately 33 percent of the total district harvest of about 587,000 pounds. The second largest fraction of the overall harvest has occurred in Berners Bay and totaled approximately 151,000 pounds, or 26 percent of the total district harvest.

Commercial, Subsistence, and Personal Use Harvest – *C. bairdi* supports significant Alaska commercial fisheries in Registration Area A of Region I (northern southeast Alaska). As with the Dungeness crab fishery, southeast Alaska is a super exclusive registration area, and has been for Tanner crab since 1985. Since 1989 the season starting date has been February 15, and the length of the season has become more or less one week. Although the average harvest for this species in southeast Alaska for the last 10 years (1991-92 and 2000-01) has been close to 2 million pounds, recent trends suggest that it probably is not a sustainable harvest level (ADF&G, 2002d).

4.5 Affected Environment Summary

As described in the preceding sections, the proposed project area has the potential to support several commercially important fish species, forage fish species, and crab species. Several species or groups have been designated as EFH species in Lynn Canal (sablefish, yelloweye and other rockfish species, sculpins, skates, Pacific salmon, Pacific herring, eulachon, capelin, and sandlance). Certain locations potentially impacted by the project alternatives have been identified as supporting various life stages of these EFH species. These locations in particular include the proposed ferry terminal location at William Henry Bay, which has been identified as supporting both anadromous and resident fish populations, and the other potential ferry terminal locations at Sawmill Cove, Slate Cove, and north of the Katzehin River.

Table 4-1
Subtidal Fill/Sidecasting Sites

Site	No. Classified Points	Min Depth (feet)	Max Depth (feet)	Physical Description	Biotic Description	Eelgrass	Stalked Kelps
Lynn Canal A1, A2 & STN 1	1,498	+8.0 intertidal	100	• very steep shoreline • substrate all clastic sediment • sediment mostly boulder-cobble with a small patch of mud at north end of site • high concentrations of shell fragments in subtidal at north end of site • no man-made objects were observed	• total vegetation cover highest near shore but subtidal covers of 25-75% common • coralline red algae, foliose red algae, and agarum are common at site • a few bladed kelps and filamentous red algae noted with very low covers (<5%) • green urchins and pycnopodia are common in shallow water, particularly at the north end of the site • the deeper areas are characterized by a bryozoan complex and bivalve (north end) • barnacles (intertidal), anemones, sea whips, unidentified fish and mottled stars were seen but are uncommon	none	none
Lynn Canal STN 2, STN 3, STN 4 & STN 5	1,005	+11.5 intertidal	128	• very steep shoreline • the site has a mixture of bedrock, sediment veneer over bedrock, and sediment • where sediment does occur, it is coarse boulders and cobbles • a significant amount of shell fragments were noted • no man-made objects were observed	• there is high vegetation cover at the site; although coralline algae is a significant component of the cover, agarum is also common • bladed kelp and foliose reds are uncommon • urchins are common in the shallow subtidal • bryozoan complexes dominate the deeper portion of the site • unidentified fish were common, with over 46 noted • stars (mottled, *Pycnopodia,* and unidentified) and anemones were present but uncommon	none	none

Table 4-1 (continued)
Subtidal Fill/Sidecasting Sites

Site	No. Classified Points	Min Depth (feet)	Max Depth (feet)	Physical Description	Biotic Description	Eelgrass	Stalked Kelps
Lynn Canal STN 6, STN 7 & STN 8	932	+11.5 intertidal	118	• bedrock crops out along the shore of the north portion of the site and in several deeper portions, though sediment is the most common substrate • sediments are virtually all gravel and dominated by boulder-cobble • shell fragments were noted throughout but at low covers (<5%) • no man-made objects were observed	• vegetation cover is highly variable and coralline red algae is a significant component of the higher cover areas • bladed kelps, fucus, filamentous red algae, and foliose red algae occur at the site but are uncommon • barnacles, green sea urchins, and mussels were noted but are uncommon • deeper areas of the site are dominated by a bryozoan complex • fish (unidentified) were fairly common (44 noted)	none	none
Low Point T1-1	633	+6.5 intertidal	125	• some intertidal sections of the site were completely obscured by vegetation • bedrock crops out in the deeper, subtidal portion at the southern end • most substrate is sediment; intertidal sediment is mostly boulder-cobble • offshore sediment is mostly slightly gravelly mud/sand • shell fragments are sparsely distributed throughout site with higher concentrations associated with bedrock • no man-made objects were	• vegetation cover was restricted to intertidal portions of the site; no vegetation was noted in the subtidal • intertidal portions are dominated by bladed kelps and coralline red algae • filamentous red algae was noted but is rare • mussels (*Mytilus trossulus*) are common in the intertidal • at deeper portions of the site (>50 feet), mussels (unidentified), shrimp, and urchins (unidentified) were common • green sea urchins (1), crab (1), and unidentified snails (5) were noted in deeper subtidal areas • unidentified fish (8) and flatfish (3) were noted	none	none

Table 4-1 (continued)
Subtidal Fill/Sidecasting Sites

Site	No. Classified Points	Min Depth (feet)	Max Depth (feet)	Physical Description	Biotic Description	Eelgrass	Stalked Kelps
Taiya Inlet STN 9	496	0	148	• a discontinuous sediment veneer of mud covers bedrock throughout most of the site • no gravel was noted • a single concrete block was the only man-made object observed	• the sparse vegetation that occurs is all coralline algae • mussels (unidentified), shrimp, and urchins (unidentified) are all common in the subtidal portion of the site • green sea urchins, mussels (*Mytilus trossulus*), bryozoan complexes, and snails (unidentified) were noted but are uncommon	none	none
Taiya Inlet STN 10, T2-1 & T3-1	718	+6.5 intertidal	138	• rock, sediment veneers over rock and sediment occur in almost equal amounts at the site • sediment is all mud • shell fragments are common over the site and approximately a third of the observations have >30% shell cover • no man-made objects were	• vegetation occurs in the intertidal portion of the site and consists primarily as coralline algae and foliose green algae • mussels (*Mytilus trossulus*) are the most common macro fauna observed in the imagery • mussels (unidentified) and urchins are common in the subtidal • shrimp are very common • bryozoan complexes were noted but are rare	none	none
Taiya Inlet T4-1	1,347	-10.5	128	• bedrock and boulder-cobble dominate the intertidal area • discontinuous mud covers bedrock in the subtidal • some subtidal portions are all mud • shell is common and there are some areas with more than 50% shell cover • no man-made objects were noted	• vegetation cover is high (>25%) in the intertidal and shallow subtidal • bladed kelp, coralline algae, and fucus contribute most to the cover canopy • filamentous red algae and foliose green algae were noted but are uncommon • the intertidal shows a dense barnacle-mussel community • mussels (unidentified), shrimp and urchins (unidentified) are common in the subtidal	none	none

Table 4-1 (continued)
Subtidal Fill/Sidecasting Sites

Site	No. Classified Points	Min Depth (feet)	Max Depth (feet)	Physical Description	Biotic Description	Eelgrass	Stalked Kelps
Taiya Inlet STN 12 & STN 13	1,146	+10 intertidal	148	• substrate is highly variable with bedrock dominating the intertidal and shallow subtidal and sediment veneers of mud to gravel in the offshore • boulder-cobble is more common on the south part of the site in both the intertidal and subtidal • high shell fragment cover	• total vegetation cover is low; highest in intertidal • blade kelps, foliose green algae, and coralline algae are common vegetation types (but not abundant) • filamentous red algae and fucus occur but are uncommon • barnacles and mussels are common in the intertidal • anemones and bryozoan complexes are uncommon	none	none
Taiya Inlet STN 11	399	+9 intertidal	154	• bedrock dominates the intertidal and subtidal • a discontinuous veneer of mud covers the subtidal bedrock • no man-made objectives were observed	• total vegetation covers are low • bladed kelps, coralline red algae, and foliose green algae are uncommon • barnacles and mussels are common in the intertidal but low cover • bryozoan complexes occur but are uncommon • subtidal mussels (mid depths) and shrimp (deep) are common • urchins are common in two patches but absent throughout the rest of the site	none	none

Table 4-2
Species Observed During 2003 Intertidal Survey
Lynn Canal, Alaska

Scientific Name	Common Name
Chlorophyta	Green Algae
Cladophora spp.	Filamentous green algae
Codium setchellii	Smooth spongy cushion
Prasiola meridionalis	Emerald carpet
Acrosiphonia arcta	Arctic sea moss (filamentous green algae)
Ulothrix flacca	Mermaid's tresses (filamentous green algae)
Enteromorpha intestinalis	Sea hair (filamentous green algae)
Enteromorpha linza	Green string lettuce
Ulva fenestrata	Sea lettuce
Rhodophyta	Red Algae
Porphyra cuneiformis	Red cellophane algae
Palmaria hecatensis	Stiff red ribbon
Hildenbrandia rubra	Rusty rock
Corallinacea, unidentified	Encrusting coralline algae
Mastocarpus papillatus	Tar spot
Odonthalia floccose	Rockweed brush
Polysiphonia spp. or *Pterosiphonia spp.*	Polly pacific or black tassel (filamentous red algae)
Phaeophyta	Brown Algae
Chordaria flagelliformis	Chocolate pencils
Pilayella littoralis	Sea felt
Soranthera ulvoidea	Studded sea balloons
Scytosiphon simplicissimus	Soda straws
Alaria spp.	Ribbon kelp
Laminaria spp.	Kelp (split, sugar, southern stiff-stiped, or suction-cup)
Fucus gardneri	Rockweed
Porifera	Sponges
Halichondria panacea	Crumb-of-bread sponge
Cnidaria	Soft-Bodied
Scyphozoans, juvenile	Sea jellies
Anthopleura artemisia	Burrowing green anemone
Mollusca	Molluscs
Tonicella lineata	Lined chiton
Lottia strigatella	Strigate limpet
Tectura persona	Mask limpet
Tectura scutum	Plate limpet
Littorina scutulata	Checkered periwinkle
Littorina sitkana	Sitka periwinkle
Nucella spp.	Dogwinkle snail
Mytilus trossulus	Pacific blue mussel
Macoma spp.	Macoma (clam)

Table 4-2 (continued)
Species Observed During 2003 Intertidal Survey
Lynn Canal, Alaska

Scientific Name	Common Name
Arthropoda	Crustaceans
Semibalanus balanoides	Northern rock barnacle
Semibalanus cariosus	Thatched barnacle
Balanus glandula	Common acorn barnacle
Idotea (Pentidotea) wosnesenskii	Rockweed isopod
Ligia pallasii	Sea slater (isopod)
Gammaridea *amphipods*	Beach flea/beach hopper
Decapoda, unidentified	Shrimp
Paralithodes spp.	King crab
Pagurus spp.	Hermit crab
Cancer marister	Dungeness crab
Echinodermata	Echinoderms
Asteriidae, unidentified	Sea star
Evasterias troschelii	Mottled star
Leptasterias epichlora	Six-armed sea star
Strongylocentrotus droebachiensis	Green sea urchin
Strongylocentrotus purpuratus	Purple sea urchin
Pisces	Fish
Cottidae, unidentified	Sculpin
Pholis spp.	Gunnel
Pholis laeta	Crescent gunnel
Onchorhynchus gorbuscha	Pink salmon

5.0 ANALYSIS OF EFFECTS TO ESSENTIAL FISH HABITAT

The following sections describe the potential direct, indirect, and cumulative effects of the nine proposed project alternatives and the No Action alternative on anadromous and marine EFH and marine EFH species in the project area, as described in Section 1.2. As applicable, the sections are organized according to the effects of highway, bridge, and/or ferry terminal construction, and the operation and maintenance associated with these alternatives, on EFH and species. This report, as well as the *Anadromous and Resident Fish Streams Technical Report* provides an analysis of the effects of the highway and bridge construction (i.e., support piles for multi-span bridges, and in-water fill placement for piling placement in only the Chilkat River) and maintenance and operations on anadromous EFH. In this report, the effects of each alternative are discussed first, followed by the cumulative effects analysis. An analysis of the indirect and cumulative effects of the project alternatives on all aspects of the affected environment is also presented in the *Indirect and Cumulative Effects Technical Report* (Appendix U to the SDEIS). Information regarding potential impacts of each alternative on marine EFH species is discussed based on available life history information for these species as presented in Section 4.3.

5.1 Alternative 1 – No Action Alternative

Under this alternative, no new highways or ferry terminals would be constructed. Modification of the ferry terminal at Auke Bay for use by the *FVF Fairweather* was completed in Spring 2004 as an independent project. The No Action Alternative includes a minimum of three mainline vessel round trips per week through Lynn Canal year-round between Auke Bay, Haines, and Skagway; a conventional monohull shuttle operating year-round between Haines and Skagway; and the *FVF Fairweather* operating between Juneau and Haines/Skagway five days per week in summer, two days per week in winter. Impacts from Alternative 1 are limited to the maintenance and operations of the ferry terminals and vessels. For this reason, the following discussion of Alternative 1 is organized without the subheadings found under the other alternatives.

An EFH Assessment completed earlier in 2003 for the ferry terminal modifications to accommodate the F/V Fairweather at Auke Bay indicated that the work had the potential to adversely impact all five species of Pacific salmon, (DOT&PF, 2003a). However, based on the scope and nature of impacts expected and the mitigation measures proposed, DOT&PF (in consultation with NMFS and on behalf of the FHWA) determined that there would be no substantial adverse individual or cumulative effects on EFH in the project area at Auke Bay. The assessment also indicated that, in addition to the five species of salmon, flounder, pollock, and several species of sole, sculpins pacific cod, and Pacific herring could use the nearshore area of the project site. These species and potential impacts are discussed in detail in the assessment (DOT&PF, 2003a).

Sculpins have been collected in beach seines near Skagway, and divers observed sculpins in the area of the Haines harbor (USACE, 2002). These fish could potentially be found near or at the other two ferry terminal sites under this alternative at Auke Bay and Haines. The other designated EFH species described in Section 4.3 have not been documented in the immediate vicinity of the terminals at Haines and Skagway. However, impacts to marine EFH species from continued operations at the existing ferry terminals would occur. Modification or replacement of natural substrates at the Auke Bay ferry terminal caused by ferry terminal operations could inhibit potential future spawning activities by herring if a larger spawning population were to return to the bay.

While no anadromous streams in the immediate vicinity of the existing ferry terminal at Haines have been documented in the Catalog, a small, anadromous unnamed stream (Catalog #115-34-10310) drains into the harbor near the terminal at Skagway, and several anadromous streams drain into Auke Bay (Auk Nu Creek: Catalog #111-50-10350, Waydelich Creek: #111-50-10370, Bay Creek: #111-50-10390, and Auke Creek: #111-50-10420). These streams were not surveyed in 1994; however, they are listed in the Catalog (ADF&G, 2003a).

In addition to the EFH species discussed above, crabs could be present in nearshore areas at all three existing terminal locations. In late winter, adult red king crab return to nearshore areas; young-of-the year red and blue king crab require nearshore shallow habitat with protective cover. Early juvenile bairdi Tanner crab also occupy shallow waters and mud habitat. Should any of these species be present in the vicinity of the terminals, disturbance due to ferry terminal operations could impact their survival.

Due to the distance of anadromous streams from the existing ferry terminals at Skagway and Haines, effects of continued ferry terminal activities or terminal modifications on anadromous streams would not occur. Due to the lack of knowledge regarding eulachon dependence on nearshore habitats, it is unknown whether eulachon at any life history stage would be affected by human disturbances typically associated with ferry terminal or vessel operations at the existing terminals (see Attachment C, Section 5.2.2.2).

Sanitary waste from discharge from marine vessels and the discharge treatment plant at the terminal are two possible sources of contaminants that could affect the water quality of marine and anadromous EFH. AMHS ferries currently use an on-board, on-demand, automated, continuous chlorinated maceration system to treat sanitary wastes. The treated effluent is discharged into marine waters. Effluent samples are taken periodically and tested for fecal coliform (FC) and total suspended solids (TSS). As reported in the *Hydrology and Water Quality Technical Report*, current ferry discharges can have FC concentrations, in particular, well above the standard. Dilution upon discharge, however, greatly reduces potential impacts from high FC concentrations. However, if discharges occur in sheltered areas void of much current, impacts to Pacific salmon, Pacific herring, crab, and sculpin EFH may be more pronounced, but localized. Such impacts could include eutrophication and chronic chlorine contamination. It is unclear whether eulachon habitat would be impacted by possible discharges (see Attachment C).

Beginning in 2004, ferries must meet Alaska water quality standards for FC and TSS or have an Alaska Department of Environmental Conservation (ADEC)-approved Interim Protective Measures Plan. Prior to 2008, the ferries used under this alternative would have sanitary waste holding tanks[1] (shuttle ferries) or would discharge treated wastewater meeting applicable standards (FVF and other AMHS ferries). The sanitary waste holding tanks would be pumped out and the waste would be treated onshore at an appropriate treatment plant. Required plans must describe the methods and timetables that AMHS will follow to ensure that the ferry discharges will meet both FC and TSS water quality standards. For these reasons, future discharges of treated wastewater from ferries in Lynn Canal should have no impact on EFH or fish species.

Sanitary liquid wastes from the existing terminal facilities undergo tertiary treatment and disinfection with ultraviolet (UV) light. The liquids are discharged via an outfall into the waters of Lynn Canal.

[1] Holding tanks would be pumped out and the waste treated onshore for disposal.

Existing AMHS ferry operations could cause short-term impacts to water quality due to unintentional fuel discharge. To date, no in-water fuel spills have been associated with AMHS ferry operations in Lynn Canal. The effects from an unintentional fuel spill would depend on the size and the location of the spill. If these discharges were to occur in calm sheltered areas, impacts to habitat may be more pronounced and could result in localized, short-term degradation of Pacific salmon, Pacific herring, crab, and sculpin habitat, and possibly eulachon habitat (due to habitat distribution and use patterns, see Attachment C). Any changes to water quality could impact the habitat of anadromous and marine fish using the nearshore areas for spawning and rearing.

Propeller wash and wakes from ferry operations may increase wave action, displacing fish eggs and larvae from shallow shoreline habitats. Wakes from some high-speed ferries have a longer wave than conventional ships that may lead to substantial wave action in shallow nearshore areas (Parnell and Kofoed-Hansen, 2001), however Alaska high-speed ferries are purported to have a shallower draft and smaller wakes than conventional craft (see Attachment C). Additionally, operation of marine vessels can cause sediment scouring that impacts submerged vegetation and benthic communities, and increase turbidity. Laboratory flume studies on the potential effect of ferry propeller wash on eelgrass from increased current velocities found that velocities above 100 centimeters/second caused significant sediment erosion and extensive damage to eelgrass rhizomes (Hart Crowser, Battelle, and Hartman Associates, 1997). Increased turbidity and propeller wash could impact the EFH of marine fish and crabs using the nearshore areas in the vicinity of existing ferry terminals for spawning and rearing. However, because EFH in these terminal areas is already disturbed, and nearshore habitat around Lynn Canal is extensive, localized, periodic disturbances and increased turbidity at existing ferry terminals from ferry operations does not have population-level effects on EFH species or crabs.

5.2 Alternative 2 – East Lynn Canal Highway with Katzehin Ferry Terminal

This alternative would construct a 68.5-mile two-lane highway from the end of the Glacier Highway at Echo Cove north around Berners Bay and along the eastern coast of Lynn Canal and Taiya Inlet to Skagway. The highway would cross nine streams that are known to support populations of anadromous fish[2]: Sawmill Creek, an unnamed creek south of Antler River, Antler River, Berners/Lace River, Slate Creek, Sweeny Creek, Sherman Creek, an unnamed creek north of Comet, and the Katzehin River. Three of these anadromous rivers, the Antler, Berners/Lace, and Katzehin rivers, would require multi-span bridges with in-stream piers. Single-span bridges constructed without in-stream piers would cross the remaining identified anadromous fish streams. A new ferry terminal would be constructed north of the Katzehin River delta and the *M/V Aurora* would be used for shuttle service between Katzehin and the Lutak Ferry Terminal in Haines. Mainline AMHS service would end at Auke Bay, and the Haines to Skagway shuttle service would be discontinued. The *M/V Fairweather* would no longer operate in Lynn Canal.

5.2.1 Construction Impacts

5.2.1.1 Effects of Highway Construction

Highway construction impacts from Alternative 2 that could affect marine and anadromous EFH include: blasting; excavating; placing clean fill material, and depositing materials from sidecasting into intertidal and subtidal areas; constructing temporary barge landing sites (to access upland construction field camps); runoff flowing from construction activities; and

[2] The streams crossed are either confirmed by ADF&G/OHMP (ADF&G, 2003a), or by the 1994 field study conducted for the 1997 Juneau Access Improvements Draft Environmental Impact Statement (EIS) as supporting anadromous fish populations.

installing support piles and falsework (falsework may not be required in all instances) in anadromous streams for multi-span bridges that require in-stream piers. Highway and bridge construction impacts are discussed separately.

Highway – The majority of the sites visited during the 2003 intertidal field study, along the alignment for Alternative 2, consisted of beaches with varying combinations of boulder, cobble, gravel, sand, and/or mud substrates. Beach types ranged from gravel/sand beaches in protected cove areas to steep boulder beaches exposed to potentially significant wave actions. Small fish such as crescent gunnels *(Pholis laeta*) and sculpins were observed in tidal pools at many of the protected sites. Crab carcasses were observed at several sites and unidentified crabs were observed at three subtidal locations. The more protected sites could be used by sculpins and crabs for spawning, rearing, and/or growth to maturity. The more exposed, steep boulder beaches are less likely to serve as spawning or rearing areas for the species considered in this assessment.

Subtidal fill/sidecasting sites investigated along the Alternative 2 highway alignment were found to support vegetation (algae), ranging in amounts from sparse to over 25% (STN 1 through 5, and T4-1), but no eelgrass beds or areas of stalked kelp were noted. Unidentified fish were observed at most every site, and shrimp were noted at several of the Taiya Inlet sites. Subtidal vegetation density of between 25 and 75% is common and was noted at sites A1, A2, and STN 1.

Section 4.2.2 describes the intertidal and subtidal conditions at sites likely to be impacted by in-water fill placement. Areas along Taiya Inlet were included in the sites assessed during the 2003 intertidal and subtidal field surveys as representative of sites potentially impacted by sidecasting. Sites EIT 4, EIT 5, and EIT 9 (see Figure 3-1 and Figure B-1 in Attachment B) are representative of intertidal areas likely to be within a sidecasting area in Taiya Inlet (Table 3-7). Although neither EIT 4 nor EIT 5 are within the current alignment, the substrate and habitat at these sites is expected to be similar to areas along Taiya Inlet that could be impacted by sidecasting. These sites are composed of bedrock cliffs or vertical faces and exhibit typical intertidal zonation with various narrow band combinations of *Fucus*, mussels, barnacles, and *Verrucaria*. Sites STN 12 and STN 13, STN 11 and T3-1 are representative of subtidal areas where sidecasting may occur during highway construction in Taiya Inlet (Figure 3-1 and Table 4-1). Site STN 12 and STN 13 have a variable subtidal substrate, with bedrock dominating the shallow subtidal and sediment veneers of mud to gravel in the deeper areas surveyed to a depth of 148 feet. Site STN 11 subtidal substrate is dominated by bedrock with a discontinuous mud veneer. Site T3-1 subtidal substrate varies from rock to sediment veneers over rock. Shrimp were observed at all three of the subtidal sites and three unidentified fish were observed at sites STN 12 and STN 13. While these intertidal and subtidal sites may support prey organisms for species being considered in this assessment, they are not likely to serve as refuge or areas important for the spawning, breeding, or growth to maturity of the EFH species.

The intertidal areas along Taiya Inlet are typically narrow and steep, and much of the sidecast material would pass by them and settle in the adjacent subtidal zone. The sidecasting would be dispersed unevenly over a broad area along the shore down steep slopes, and would not produce substantially different habitat than already exists except where the bottom consists of mud. Sidecasting would create a sediment plume that could smother benthic organisms in an area outside the principal zone of deposition, but it would not occur in intertidal or subtidal areas that would likely serve as refuge or areas identified as important to EFH species. For these reasons, effects on EFH due to sidecasting of materials in intertidal areas would not be measurable.

In order to allow access to upland construction field camps, temporary barge landing sites would be necessary along the Alternative 2 highway alignment south of Taiya Inlet. These sites would be identified during highway design, and would utilize existing access locations, previously disturbed areas, and highway fill locations where practicable; therefore impacts to EFH would be minimized. At the conclusion of construction, or at the point when the landing sites are no longer needed, the sites would be demobilized, and the original beach material and grade would be restored and revegetated as applicable. Impacts to the intertidal zone and EFH would occur, but all sites would be rehabilitated to acceptable standards.

As described in Section 4.3.6.1, the spawning location for Pacific herring in Lynn Canal has changed considerably over the past few decades. Lynn Canal herring traditionally spawned from Auke Bay to Point Sherman, including Berners Bay. In recent years, however, spawning activity for the entire Lynn Canal herring stock is now centered between Point Bridget and the Berners Bay flats, with limited spawning in Auke Bay (see Attachment C). Under Alternative 2, intertidal herring spawning habitat in Berners Bay would not be affected by highway construction because in-water fill is not a component of this alternative in herring spawning grounds (See Attachment C).

In addition to the EFH species discussed above, crabs could be present in nearshore areas. In late winter, adult red king crab return to nearshore areas; young-of-the year red and blue king crab require nearshore shallow habitat with protective cover. Early juvenile bairdi Tanner crab also occupy shallow waters and mud habitat. Should any of these species be present in the vicinity of shoreline disturbance during highway construction, it could impact their habitat and survival.

Blasting, excavating, and placement of fill during highway construction may temporarily impact local watersheds by increasing sediment suspension in runoff to neighboring streams and nearshore areas. However, an Erosion and Sedimentation Control Plan (ESCP) developed for the project, as well as construction BMPs and the use of silt fences, would minimize impacts from construction runoff that could cause short-term impacts to water quality, thereby degrading marine EFH. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

Stream Crossing Structures – Stream crossings for a highway would involve construction of single-span bridges without in-stream piers, or multi-span bridge structures with in-stream piers depending on the size of the anadromous stream crossing. Typical construction techniques for multi-span structures include the erection of falsework (falsework may not be required in all instances) to provide a platform for equipment, thereby eliminating the need for equipment to be active in the river bottom. When sensitive receptors are expected to be in the area, vibratory equipment would be used to drive the support piles. If no sensitive receptors such as migrating salmon or eulachon are expected, a percussion method would be used.

Single-span bridges do not encroach upon the stream banks and require minimal modification of the stream profile. Construction activities would be staged from the bridge abutments, and construction equipment would not be used within the anadromous fish streams. In-stream construction is generally restricted to the period from mid-June through mid-August to avoid sensitive life stages of salmon, and as mentioned above, would be timed to avoid other species' sensitive life stages as well. There would be short-term increases in turbidity during construction of all three multi-span bridges. It is not expected that the increases in turbidity would be noticeable during the summer relative to the ambient turbidity in the Antler, Berners/Lace, and Katzehin rivers; however, there are situations where high flows during summer make in-stream construction very challenging. In certain cases, the (OHMP) may permit in-stream work for the winter months (the clear water period) when the channel is frozen and/or flow is minimal. A winter work window would only be authorized if the overall construction impacts were deemed to be less than if the work were to occur during the summer. For any construction window, BMPs would be specified to control turbidity during bridge construction.

Tidal channels with small unidentified fish were observed during the 2003 field survey near the Katzehin River crossing EIT 13; (see Figure B-4 in Attachment B). The delta of the Katzehin River is considered EFH not only for coho and chum salmon, but also for eulachon. If construction occurred during spawning runs or sensitive life stages of anadromous fish (early spring for eulachon, late summer for salmon), there would be some short-term effects (e.g., noise and vibration) that could influence migratory behavior, upstream swimming capabilities, and spawning success of adult fish, as well as the development of their eggs, especially for eulachon (see Attachment C). However, in-water construction windows would be implemented to minimize impacts during sensitive life stages of the fish, and it is expected that fish could avoid the disturbance by moving to one of the numerous tidal channels at the river where the construction is not occurring, because not all tidal channels would be impacted at the same time (i.e., bridge construction would either occur from one side of the river to the other or both sides to the middle).

Large and historic eulachon spawning runs have occurred in and around the Antler and Berners/Lace rivers. To help minimize effects due to construction of the multi-span bridges, the bridge crossings would be located above the sand flats where pre-spawning adult eulachon aggregate. As mentioned above, in-water construction windows would be implemented to reduce impacts on the species' sensitive life stages. Once in place, the multi-span bridge piers, which would be placed approximately 120 feet apart, would not impede fish movement within these three rivers.

5.2.1.2 Effects of Ferry Terminal Construction

Ferry terminal construction impacts from Alternative 2 that could affect marine and anadromous EFH would stem from: excavating, placing clean fill material in intertidal and subtidal areas for the ferry terminal/parking area and possible breakwater structure, installing piers or piles for the ferry dock, and dredging.

An intertidal study was conducted near the proposed terminal site north of the Katzehin River (EIT 11; see Section 4.2.1.3). The ferry terminal site consists of a steep boulder beach, transitioning to a less steep cobble beach. The subtidal survey of the area found two distinct environments: a boulder-cobble-gravel substrate in the upper subtidal/lower intertidal zone and a muddy substrate in the lower subtidal zone. Although the percentage of good images was low for the survey, there were an adequate number of interpretable images that were all consistent with one another. Refer to Section 4.1.1.3 for a discussion of the adequacy of the subtidal survey at the Katzehin Ferry Terminal site. Vegetation was observed in the more shallow areas, but not in deeper subtidal areas. Stalked kelps occurred along one section of the lower intertidal area, but no seabed vegetation was seen in the video imagery from the lower subtidal zone. A low density of fauna was observed in the subtidal video imagery; only a few unidentified fish, including several flatfish and a single anemone were observed. No sea grasses or kelps were observed in the subtidal zone. Due to the steepness of the beach, potential wave exposure, and lack of subtidal vegetation, this site is considered less productive as EFH for use by EFH and crab species than more protected coves.

Due to severe weather exposure at this site, and the potential need for wave protection, three layouts for the Katzehin Ferry Terminal were evaluated (DOT&PF, 2003b). The evaluation identified one layout (Layout #2) as the preferred design as it provides enhanced weather protection while balancing costs and environmental impact. Layout #2 includes rubble mound breakwater structures sited to the north and south of a dredged mooring basin. A vehicle transfer bridge supported by a float would be used for berthing/loading the vessel. The breakwaters would provide suitable protection from the predominant northerly and southerly waves; however, exposure to the west would still be evident.

During construction, fill would be placed from the landward side outward, avoiding in-water use of construction equipment. Typically, breasting dolphins for the ferry terminal are driven utilizing equipment staged on a floating barge. Dredging would also occur from a barge. Dredged materials would be used as much as possible as basis for the fill; however, it is likely that some amount of dredged materials would need to be disposed according to applicable regulations. Additional placement of in-water fill is required for the ferry terminal building/parking area, which would bury all intertidal and subtidal organisms present at the in-water fill locations.

EFH and crab species potentially present in the vicinity would likely experience short-term disturbance from noise and vibrations during dredging and pile driving. As described above for bridge construction (see Section 5.2.1.1, Stream Crossing Structures), piers or piles needed for the terminal would be placed using either vibratory or percussion methods. If sensitive species such as migrating eulachon or salmon were expected in the area, the less-disruptive vibratory methods would be used. Due to the low productivity potential of the Katzehin site, and the opportunistic nature of the EFH and crab species observed during the 2003 field surveys, the effects of terminal construction on EFH are expected to be small.

There would be no effects on anadromous EFH due to the distance between the Katzehin Ferry Terminal and the Katzehin River and other anadromous streams. Eulachon are not expected to use the nearshore areas at the Katzehin terminal site (see Attachment C).

The effects of dredging and placement of fill during terminal construction would cause short-term impacts to water quality by increasing sediment suspension in the water column, resulting in degradation of marine habitat. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

5.2.2 Long-Term Impacts

5.2.2.1 Effects of Highway Fill

For the Alternative 2 alignment, 21.9 acres of intertidal/subtidal area would be filled for highway construction. Habitat types potentially affected include sediment beaches (EIT 6, EIT 9, EIT 11, EIT 13, EIT 14, EIT 20, EIT 21, EIT 35, EIT 36, and EIT 37), bedrock cliffs (EIT 18 and 19), and sites where beaches and cliffs are both present (EIT 22 through EIT 26, and EIT 28). One additional site (EIT 12) is a wetland/slough location. The placement of fill would eliminate existing EFH in these areas. Intertidal and subtidal species observed in the 2003 field surveys are opportunistic and the slopes of fill areas would likely be colonized by similar intertidal and subtidal species over a few seasons. However, because the amount and character of the area available for recolonization would be different from the undisturbed intertidal zone, recolonization would not restore the community to its original state, thereby reducing its value as foraging habitat for EFH and crab species. Therefore, depending on the individual area's use by EFH and crab species for spawning, rearing, and/or growth to maturity (protected coves are likely to be used more as compared to exposed steep boulder beaches), and its ability to recolonize, the direct effects on marine EFH of placing in-water fill in specific intertidal and subtidal zones would be realized throughout the 26 acres. However, relative to the total available EFH in Lynn Canal, this fill would not affect regional populations of fish or invertebrate species or the overall quality of available EFH.

5.2.2.2 Effects of Highway Maintenance and Operations

Results from stormwater research by the FHWA indicate that stormwater runoff from low to medium traffic volumes (under 30,000 vehicles per day) on rural highways exerts minimal to no impact on the aquatic components of most receiving waters (USDOT & FHWA, 1987). Studies conducted in Anchorage, Alaska, under the Municipality of Alaska Watershed Management Program similarly concluded that street runoff has minimal impacts to the water quality of receiving waters from most potential pollutants (MOA 2000b). These studies showed dissolved concentrations of calcium, chromium, magnesium, and zinc to be below their Alaska Water Quality Standards (AWQSs). Only dissolved concentrations of copper and lead were noted to be above their AWQSs; however, modest dilution would likely reduce these concentrations below their AWQSs. Identified concentrations would not adversely impact streams with flow rates greater than 0.5 cubic foot per second (MOA, 2000e). Polynuclear aromatic hydrocarbons were at concentrations below the EPA water quality criteria.

Because of the rural setting of an East Lynn Canal Highway and the predicted low average daily traffic (ADT), fewer impacts to water quality in the project area would occur than were found in the Anchorage studies. Studied runoff was collected from Anchorage roadways that ranged from residential (<2,000 ADT) to major arterial (>20,000 ADT). Studied melt water was from snow collected from a mix of these types of roads. In comparison, Alternative 2 would have a maximum peak week ADT in 2008 and 2038 of 1,800 and 3,250 vehicles, respectively. During all but that week, ADT would be on the order of less than 1,000 vehicles per day.

Highway runoff and melt water from Alternative 2 would have lesser quantities of potential contaminants than what was observed in the Anchorage studies due to a lower traffic volume and less development in the Lynn Canal corridor. Snow would be cleared from the highway and deposited along its length, instead of being disposed of in one location. DOT&PF does not usually use deicing chemicals on rural roads. Sanding would be performed, as conditions required. Typically, up to 5% sodium chloride per total weight of sand is added to keep sand friable in winter. Potential pollutants would not be concentrated in one area. Runoff from the proposed highway and bridges would not exceed AWQS standards or adversely impact the water quality of receiving waters for the long term. Potential contamination from oil or hazardous substance spills would be low due to the rural setting of the highway and the low predicted highway traffic volume.

Historic and current Pacific herring spawning habitat is found in Berners Bay. The distance between the alignment and shoreline is generally 500 to 2,000 feet around Berners Bay, except for the corridor between Sawmill Cove and the flats in upper Berners Bay (known as Berners Bay Flats), where less than 10% of the highway approaches within 200 feet of the shoreline and spawning habitats (see Attachment C). Elevated turbidity has the potential to suffocate Pacific herring eggs, which are also very susceptible to the effects of nuisance algae blooms brought about by nutrient enrichment in local streams and nearshore receiving waters, but a vegetated buffer 200 feet wide would serve to filter out pollutants and moderate effects of erosion. Therefore, runoff or disturbance associated with normal highway operations would not reach or substantially alter shoreline habitats in Berners Bay near known herring spawning areas.

5.2.2.3 Effects of Ferry Terminal Dredge and Fill

Alternative 2 discontinues the No Action Alternative mainline and *FVF Fairweather* service in Lynn Canal, but includes a shuttle ferry between Katzehin and Haines. Approximately 4.3 acres of intertidal sediment beach and subtidal area would be buried at the Katzehin location with fill and would no longer be available for colonization, and 4.5 acres of subtidal boulder/cobble/gravel habitat would be affected by dredging for the new terminal (DOT&PF, 2003b).

Intertidal and subtidal species observed in the 2003 field surveys are opportunistic, so slopes of fill areas could be colonized by similar intertidal and subtidal species over a few seasons. While the slopes of the filled area would be available for colonization by subtidal and intertidal species, the amount and character of this substrate would differ from the natural habitat, thereby reducing its value as foraging habitat for EFH and crab species. Although breakwater structures could influence local hydrology by changing the flow of water over adjacent substrates, and causing scouring, changes in bathymetry and flushing rates, and alteration of sediment transport (Nightingale and Simenstad, 2001), for reasons mentioned above, no EFH or crab species are expected to be affected (see Appendix C).

5.2.2.4 Effects of Ferry Terminal Maintenance and Operations

Operation of this ferry system would not impact Pacific salmon, Pacific herring, or eulachon because of the spatial separation between the terminal and the Katzehin River and other areas of Lynn Canal important to these species such as Berners Bay for eulachon and herring. However, for sculpin, an effect due to disturbance could be realized. There is a potential for increased turbidity at the terminal location due to vessel maneuvering within the basin, but because dredging and placement of fill would have already modified the habitat, additional impacts from the increased turbidity would not be expected.

Sanitary wastewater discharged from marine vessels and the treatment plant at the Katzehin Ferry Terminal are two possible sources of contaminants that could affect marine and anadromous EFH. Both of these forms of waste will be highly regulated so the possibility of any effect would be low. The ferries used under Alternative 2 would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. The sanitary waste holding tanks would be pumped out and the waste would be treated onshore at an appropriate treatment plant. Wastewater from the Katzehin terminal facility would undergo tertiary treatment including disinfection with UV light. The liquids would then be discharged under the NPDES General Permit for small publicly-owned treatment works or other small works discharging into marine waters (#AKG-57-1000). The General Permit would be certified by ADEC, which could require a mixing zone if needed for the discharge to meet AWQS. The location of outfall lines from ferry terminals would be identified after design, during permitting. Solids would be separated from liquids and the sludge would be disposed of at an appropriate sewage treatment plant. For these reasons, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal.

5.2.3 Summary of Alternative 2 Impacts

Overall, this alternative includes the construction of about 69 miles of highway, three multi-span and six single-span bridges, and one ferry terminal. Approximately 30.7 acres of intertidal/subtidal habitat would be buried or otherwise impacted under the alternative (21.9 acres from construction of the highway and 8.8 acres dredged or filled at the Katzehin Ferry Terminal site).

Ferry terminal basin and building/parking area construction activities at the Katzehin location would have effects on intertidal sediment beaches and subtidal mud bottom marine EFH. No impacts on the sparse subtidal vegetation are expected at the site. No effects on anadromous EFH would be expected at the Katzehin Ferry Terminal site due to its distance from the Katzehin River or other anadromous streams. In addition, in-water construction windows would be established if necessary to protect anadromous and marine species.

Effects on marine EFH from highway construction would occur due to the presence of fill or disposal of materials during sidecasting. Placement of fill would bury all intertidal and subtidal organisms at the specific fill locations. Although these species are opportunistic, recolonization would be affected due to changes in the available substrate, thereby reducing its value as foraging habitat for EFH and crab species. Intertidal herring spawning habitat in Berners Bay would not be directly affected by highway construction because in-water fill is not a component of this alternative in herring spawning grounds (See Attachment C). Temporary barge landing sites required to access construction camps would be demobilized and restored to acceptable standards.

Multi-span bridges would be required over the Antler, Berners/Lace rivers, and Katzehin rivers, and single-span bridges would be used to cross all other anadromous fish streams. There would be short-term increases in turbidity during construction of all three bridges; however, it is not expected that the increases would be noticeable against the ambient turbidity produced by the Antler, Berners/Lace rivers, and Katzehin rivers, and BMPs would be required to reduce the incidence of turbidity during construction.

Studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2 would not be large enough for runoff from the highway to cause the exceedance of any AWQSs in receiving waters. Therefore, highway maintenance and operations under this alternative would not likely lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species

The ferries used under Alternative 2 would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo tertiary treatment. Solids would be separated from liquids and the sludge would be disposed of at an appropriate sewage treatment plant. Liquids would undergo aeration and disinfection with ultraviolet light. The treated wastewater would be discharged to Lynn Canal under a NPDES permit and would meet EPA-established waste discharge limitations. For this reason, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal, including Berners Bay.

Alternative 2 would result in improved access to the east side of Lynn Canal. This is likely to result in increased recreational fishing for anadromous fish along the eastern shoreline of Lynn Canal, as well as the anadromous streams crossed by the alignment. No boat ramps would be constructed along the highway for this alternative. Therefore, they would not increase the number of access points in the project study area for boats other than small, highly portable recreational craft such as kayaks and canoes.

As discussed in Section 4.4.2 of the *Indirect and Cumulative Effects Technical Report*, Alternative 2 is projected to result in an increase in non-resident visitors and a small population increase in Juneau, Haines, and Skagway. This would increase the volume of effluent discharged from the wastewater treatment facilities in these communities. This increase would not reduce water quality in the receiving waters because these facilities must meet NPDES discharge limitations protective of aquatic life.

5.3 Alternative 2A – East Lynn Canal Highway with Berners Bay Shuttles

Alternative 2A would construct a 5.2-mile two-lane highway from the end of Glacier Highway at Echo Cove to Sawmill Cove in Berners Bay. Ferry terminals would be constructed at both Sawmill Cove and Slate Cove (thereby eliminating the road around Berners Bay), and shuttle ferries would operate between the two terminals. A 52.9-mile two-lane highway would be constructed between Slate Cove and Skagway along the eastern coast of Lynn Canal and Taiya

Inlet. The highway would cross five anadromous streams: the Katzehin River, Sawmill Creek, an unnamed stream, and Sweeny and Sherman creeks. One multi-span bridge with in-stream piers would be constructed to cross the Katzehin River and its adjacent anadromous channel, and four single-span bridges without in-stream piers would be constructed to cross the remaining streams. All other aspects of this alternative are the same as Alternative 2.

5.3.1 Construction Impacts

5.3.1.1 Effects of Highway Construction

Highway construction impacts from Alternative 2A that could affect marine and anadromous EFH would stem from: blasting; excavating; placing clean fill material, and depositing materials from sidecasting into intertidal and subtidal areas; constructing temporary barge landing sites (to access upland construction field camps); runoff flowing from construction activities; activities; and installing support piles and falsework (falsework may not be required in all instances) in anadromous streams for multi-span bridge construction.

Highway – Impacts on marine EFH would occur, due to the presence of in-water fill in intertidal and subtidal areas and at sidecast locations, and temporary barge access sites. The intertidal areas along Taiya Inlet are typically narrow and steep, and much of the sidecast material would pass by them and settle in the adjacent subtidal zone. The sidecasting would be dispersed unevenly over a broad area along the shore down steep slopes, and would not produce substantially different habitat than already exists except where the bottom consists of mud. However, the direct effects of placing fill in specific intertidal and subtidal zones depend on the individual areas use by EFH species (protected coves are likely to be used more than exposed steep boulder beaches), and its ability to recolonize. Approximately 30% of the fill sites are considered to be steep boulder beaches (refer to Section 4.2.2 for details). Intertidal herring spawning or eulachon habitat in Berners Bay would not be affected by highway construction because a highway around Berners Bay is not a component of this alternative (See Attachment C). Also as described for Alternative 2, the barge landing areas would be temporary, would be sited to avoid high use areas for fish, and the effects on EFH would be short-term because the sites would be rehabilitated to acceptable standards at the end of the construction project.

In order to allow access to upland construction field camps, barge landings would occur at the Katzehin ferry terminal and at Comet for the Alternative 2A highway alignment south of Taiya Inlet. These sites would be identified during highway design, and would utilize existing access locations, previously disturbed areas, and highway fill locations where practicable. At the conclusion of construction, or at the point when the landing sites are no longer needed, the sites would be demobilized, and the original beach material and grade would be restored and revegetated as applicable. Impacts to the intertidal zone and EFH would occur, but all sites would be rehabilitated to acceptable standards.

Blasting, excavating, and placing of fill during highway construction may temporarily impact local watersheds by increasing runoff to neighboring streams and nearshore areas. This construction runoff would cause short-term impacts to water quality, resulting in degradation of marine habitat. However, an ESCP developed for the project, as well as construction BMPs and the use of silt fences, would minimize impacts from construction runoff that could cause short-term impacts to water quality, thereby degrading marine EFH. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

Sidecasting would create a sediment plume that could smother benthic organisms for an area outside the principal fill zone, but it is expected that fish would avoid these plumes. This temporary sediment plume is not expected to have population-level effects on EFH or crab species in Lynn Canal. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

Stream Crossing Structures – For Alternative 2A, the only multi-span structure with in-stream piers would cross the Katzehin River and its adjacent anadromous channel, and the remaining four anadromous fish streams, Sawmill, Sweeny and Sherman creeks and an unnamed stream, would be crossed by single-span bridges without in-stream piers. Impacts of these structures on the anadromous streams would be as described under Alternative 2. Typical construction techniques for multi-span structures include the erection of falsework (falsework may not be required in all instances) to provide a platform for equipment, thereby eliminating the need for equipment to be active in the river bottom. When anadromous fish species are expected to be in the area, vibratory equipment would be used to drive the support piles. If no anadromous fish such as migrating salmon or eulachon are expected, a percussion method would be used.

Single-span bridges do not encroach upon the stream banks and require minimal modification of the stream profile. Construction activities would be staged from the bridge abutments, and construction equipment would not be used within the anadromous fish streams. In-stream construction is generally restricted to the period from mid-June through mid-August to avoid sensitive life stages of salmon, and would be timed to avoid other species' sensitive life stages as well. There would be short-term increases in turbidity during construction of the multi-span bridge at the Katzehin River, but it is not expected that the increases in turbidity would be noticeable during the summer relative to the ambient turbidity in the river. However, there are situations where high flows during summer make in-stream construction very challenging. In certain cases, the OHMP may permit in-stream work for the winter months (the clear water period) when the channel is frozen and/or flow is minimal. A winter work window would only be authorized if the overall construction impacts were deemed to be less than if the work were to occur during the summer. For any construction window, BMPs would be specified to control turbidity during bridge construction.

5.3.1.2 Effects of Ferry Terminal Construction

Three new ferry terminals would be constructed under this alternative: Sawmill Cove, Slate Cove, and north of the Katzehin River. The type of terminal planned for the Katzehin site would be the same as described above for Alternative 2. The type of terminal planned for Sawmill Cove would consist of a stern load berth facility including two bridge support floats and a shared dolphin system comprised of all-tide floating fenders. Access to the terminal vessels would be via twin 143-foot long steel transfer bridges founded on offshore fill (see the *Marine Terminal Concepts Report*). The terminal planned for Slate Cove would be a single side berth facility, consisting of a steel transfer bridge abutting offshore fill and supported at the seaward end by a steel bridge float (see the *Marine Terminal Concepts Report*). Features of the Slate Cove Ferry Terminal include a fixed dolphin structures with all-tide floating fenders or fixed mooring faces would be used depending on vessel needs. The staging area would be constructed on a combination of intertidal and upland fill. Local excavation of an existing beachfront bluff would be needed. Construction impacts on all three ferry terminals under Alternative 2A that could affect marine and anadromous EFH would stem from excavating, in-water placement of clean fill material for the ferry terminal/parking area and possible breakwater structure, installation of piers or piles for the ferry dock, and dredging. .

The mouth of Slate Creek and the cove were investigated during the 2003 intertidal field survey (see Section 4.1.1.2). Many clam holes were evident in the mud at and near the water level, and numerous empty *Macoma balthica* shells were observed. Mussels, rockweed, and barnacles were attached in clumps on most of the cobbles and boulders, along with patches of sea lettuce. The 2003 subtidal survey showed that the Slate Cove site has a highly uniform muddy substrate (see Section 4.1.1.2). As observed on the subtidal video, waters in the cove have a high level of ambient turbidity. A few boulders and cobbles were observed at the southern portion of the site, within the intertidal zone. No kelp or eelgrass was seen in the subtidal video imagery. Fauna was sparse and included only a few unidentified fish, a few flatfish, and a single anemone.

The subtidal surveys at Sawmill Cove observed a seabed comprised almost exclusively of muds, sand, and gravels, although there may be some bedrock outcrops on the seabed in one location. Gravel content was highest in the intertidal zone and dropped off rapidly in the subtidal zone where sands and muds predominated, with occasional larger cobble. Vegetation cover was closely linked to the gravel component; therefore cover dropped off rapidly in the offshore. Subtidal vegetation consists of sparse but persistent and evenly distributed large-bladed kelp. No eelgrass or stalked kelp was present at the site. The 2003 intertidal survey of Sawmill Cove observed a gravel cobble beach with rocky outcrops, and little vegetation. Based on a field visit on August 31, 2004, NMFS reported the intertidal vegetation consisted of dense *Fucus*, or rockweed, on the rocky points. In the low intertidal zone, rockweed was interspersed with *Lamanaria saccharina* and *Agarum clathratum* (both large-bladed kelp).

Sawmill Cove and Slate Cove Ferry Terminal sites likely support various life stages of several of the species considered in this assessment. For example, sablefish are known to rear in Berners Bay and an August 2004 survey by NMFS reported a large school of young Pacific herring near the proposed terminal site in Sawmill Cove (personal communication with Susan Walker, NMFS). Pacific herring spawn in the bay and were abundant in the past, but the stock is presently below harvestable levels. Various hypotheses have been made about why the stocks have declined, although none have been substantiated by scientific analysis. These hypotheses include one or a combination of the following factors: overfishing, increased predator populations, disease, habitat alteration/degradation, water pollution, and unfavorable oceanographic conditions. Because the herring stock in Lynn Canal is depressed, the stock is subject to increased vulnerability from impacts associated with any of these factors. For instance, increased Steller sea lion populations could be applying increased predation pressure to the stock. Eulachon spawn in the lower reaches of the Berners and Antler rivers. Skates are rare in the bay. In the subtidal zone, one location of orange sea pens *(Ptilosarcus gurneyi*) was noted in the northern third of the site (estimated at an area of 21,500 square feet; depth ranging from 50 to 80 feet). These organisms are living marine substrates and are designated as HAPC, which must be protected under the Act. Unidentified crabs were observed in the subtidal video of Sawmill Cove. Berners Bay is a popular area for harvesting king crabs.

As described for Alternative 2, an intertidal study was conducted near the proposed terminal site north of the Katzehin River (EIT 11; see Section 4.2.1.3). The ferry terminal site consists of a steep boulder beach, transitioning to a less steep cobble beach. The subtidal survey of the area found two distinct environments: a boulder-cobble-gravel substrate in the upper subtidal/lower intertidal zone and a muddy substrate in the lower subtidal zone. Vegetation was observed in the more shallow areas, but not in deeper subtidal areas. Stalked kelps occurred along one section of the lower intertidal area, but no seabed vegetation was seen in the video imagery from the lower subtidal zone. A low density of fauna was observed in the subtidal video imagery; only a few unidentified fish, including several flatfish and a single anemone were observed. No sea grasses or kelps were observed in the subtidal zone. Due to the steepness of the beach, potential wave exposure, and lack of subtidal vegetation, this site is considered less productive as EFH for use by EFH and crab species than more protected coves.

Due to severe weather exposure at this site, and the potential need for wave protection, three layouts for the Katzehin Ferry Terminal were evaluated (DOT&PF, 2003b), with Layout #2 as the preferred design because it provides enhanced weather protection while balancing costs and environmental impact. Layout #2 includes rubble mound breakwater structures sited to the north and south of a dredged mooring basin. A vehicle transfer bridge supported by a float would be used for berthing/loading the vessel. The breakwaters would provide suitable protection from the predominant northerly and southerly waves; however, exposure to the west would still be evident.

As mentioned above, due to the low productivity potential of the Katzehin site as EFH, and the opportunistic nature of the EFH and crab species observed during the 2003 field surveys, the effects of terminal construction on EFH are expected to be low.

Anadromous fish populations have been identified by OHMP at Sawmill Creek (see the *Anadromous and Resident Fish Streams Technical Report*). However, the proposed Sawmill Cove Ferry Terminal is sited over a mile north of the mouth of Sawmill Creek, at a site investigated during the 2003 intertidal survey (see Section 4.1.1.1), and therefore, no effects are expected on anadromous EFH at this site. The Katzehin River supports anadromous fish species such as coho and chum salmon. There would be no effects on anadromous EFH due to the distance between the Katzehin terminal and the Katzehin River and other anadromous streams. Because their habitat distribution and use of nearshore areas is unclear, it is unknown whether eulachon would be affected by habitat alterations associated with ferry terminal construction activities at the Katzehin site (see Attachment C). Slate Creek, located at the head of Slate Cove, has been cataloged as an anadromous stream (see the *Anadromous and Resident Fish Streams Technical Report*), and is identified as EFH for pink, chum, and other salmon. However, the proposed Slate Cove Ferry Terminal is approximately over 2,000 feet south of Slate Creek, and as explained above, would not effect anadromous EFH. In-water construction windows would be established to protect anadromous fish returning to spawn in Slate Creek.

During construction at all three ferry terminal locations, in-water fill would be placed from the landward side outward, avoiding in-water placement of construction equipment. Typically, breasting dolphins for the ferry terminal are driven utilizing equipment staged on a floating barge. Dredging at the Sawmill Cove site would also occur from a barge. Dredged materials would be used as much as possible as basis for the fill; however, it is likely that some amount of dredged materials would need to be disposed according to applicable regulations. Additional placement of in-water fill is required for the ferry terminal building/parking area at both the Sawmill Cove and Slate Cove terminal sites; this fill would bury all intertidal and subtidal organisms at the in-water fill locations. Herring eggs and larvae that are present in shallow water spawning habitats and crabs using the shallow subtidal and intertidal zones near Sawmill Cove (in particular) have some potential for direct displacement, removal, or burial (see Attachment C).

All fish and crab species present during construction would likely experience short-term disturbance from noise and vibrations during dredging and pile driving. As described previously, the method chosen for pile driving (vibratory or percussion) would depend on the incidence of anadromous species in the area during construction. There would be short-term increases in turbidity during construction; however, the increases might not be noticeable relative to the ambient turbidity within the Berners Bay area, and BMPs would be followed to limit turbidity increases during construction. This is particularly necessary due to the presence of sea pens (designated as HAPC) in the subtidal zone at the Sawmill Cove site. It may be necessary to better map the location of the sea pens in order to provide protection for the area during construction. Even though extensive kelp beds were not observed during the subtidal survey at Sawmill Cove, Pacific herring are known to spawn along the eastern shore of Berners Bay, which includes the area of the proposed Sawmill Cove Ferry Terminal. The short-term turbidity mentioned above could result in the loss of some Pacific herring eggs in the vicinity of the Sawmill Cover terminal, but is not expected to have a population effect.

Thus, the effects on fish habitat due to construction of the ferry terminals at Slate and Sawmill coves would be short-term. The effects of dredging and placement of fill during terminal construction would cause short-term impacts to water quality by increasing sediment suspension in the water column, resulting in degradation of marine habitat. The discussion of the loss of Pacific herring spawning habitat is provided under the maintenance and operations section, below.

Due to the spatial separation between the proposed terminal site at Sawmill Cove and Sawmill Creek, and the proposed terminal site at Slate Cove and Slate Creek, no effects of either ferry terminal location are expected on the anadromous EFH at either respective creek.

There exists some potential for contaminants to accumulate in nearshore sediments and affect Pacific herring egg development as well as individual sculpin, juvenile red and blue king crab, and juvenile bairdi Tanner crabs. Proper ferry terminal construction techniques and timing would minimize these indirect effects on Pacific herring, eulachon, and crabs. The impacts to sculpins would be short-term and localized.

5.3.2 Long-Term Impacts

5.3.2.1 Effects of Highway Fill

Approximately 21.9 acres of intertidal and/or subtidal EFH would be impacted due to placement of fill for the highway. The same intertidal and subtidal habitat described in Section 5.2.2.1 would be impacted by placement of fill for the highway. As described for Alternative 2, intertidal and subtidal species observed in the 2003 field surveys are opportunistic and the slopes of fill areas would likely be colonized by similar intertidal and subtidal species over a few seasons. Depending on the individual area's use by EFH and crab species for spawning, rearing, and/or growth to maturity (protected coves are likely to be used more as compared to exposed steep boulder beaches), and its ability to recolonize, the effects on marine EFH of placing in-water fill in specific intertidal and subtidal zones would be realized throughout the 21.9 acres. However, relative to the total available EFH in Lynn Canal, this fill would not affect regional populations of fish or invertebrate species or the overall quality of available EFH.

5.3.2.2 Effects of Highway Maintenance and Operations

Also as described for Alternative 2, studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2A would not be large enough for runoff from the highway to cause the exceedance of any AWQSs in receiving waters. Therefore, highway operations under this alternative would not lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species

5.3.2.3 Effects of Ferry Terminal Dredge and Fill

As described previously for Alternative 2, approximately 8.8 acres of subtidal/intertidal habitat would be coved by fill or affected by dredging at the Katzehin site. The staging area for the Slate Cove Ferry Terminal would cover a total area of about 1.1 acres of intertidal and subtidal habitat; no dredging is planned for this site. At Sawmill Cove, an area of approximately 1.3 acres would require dredging, and the building/parking (staging) area for the terminal would require about 1.9 acres of fill in the intertidal/subtidal zone. The footprint of the Sawmill Cove Ferry Terminal would impact approximately 300 feet (0.06 mile) of shoreline at MLLW, the equivalent of less than two percent of the alongshore herring spawning habitat observed in Berners Bay in 2003 (see Attachment C).

The proposed Sawmill Cove ferry terminal is located near the center of the existing spawning habitat for the depressed Lynn Canal Pacific herring in Berners Bay. The habitat in the subtidal area that would be disturbed by filling and dredging for this terminal is suitable for herring spawning. The ferry terminal would impact less than two percent of the spawning area for Pacific herring.

5.3.2.4 Effects of Ferry Terminal Maintenance and Operations

The effects of ferry terminal and ferry vessel operations under Alternative 2A would be as described for Alternative 2 at the Katzehin Ferry Terminal, with the addition of impacts from the Berners Bay shuttle terminals at Slate Cove and Sawmill Cove. As for Alternative 2, intertidal and subtidal species observed in the 2003 field surveys are opportunistic, so slopes of fill areas could be colonized by similar intertidal and subtidal species over a few seasons. While the slopes of the filled area would be available for re-colonization, the amount and character of this substrate would differ from the natural habitat, thereby reducing its value as foraging habitat for EFH and crab species. Also as described for Alternative 2, operation of this ferry system would not impact Pacific salmon, Pacific herring, or eulachon because of the spatial separation between the terminal and the Katzehin River and other areas of Lynn Canal important to these species. However, for sculpin, an effect due to disturbance could be realized. In addition, in-water construction windows would be established if necessary to protect anadromous and marine species.

Increased turbidity due to vessel maneuvering at the terminal locations would not likely be noticeable above ambient conditions. This is particularly true at Slate Cove where the substrate is composed primarily of muds that are easily resuspended by natural processes creating a high level of ambient turbidity. Therefore, effects on anadromous and marine EFH due to ferry operations would not occur. Propeller wash disturbances from boat traffic may increase loss of herring eggs found in known shallow water spawning habitats, whereas artificial lighting, noise, vessel traffic, and other human-associated activities near ferry terminals may disrupt natural behaviors (e.g., avoidance or schooling) of larval, juvenile, and adult herring (see Attachment C). Also, as discussed in 5.3.1.2, there are several factors which may contribute to the depressed condition of the herring stock, including overfishing, increased predator populations, disease, habitat alteration/degradation, water pollution, and unfavorable oceanographic conditions. Because the herring stock in Lynn Canal is depressed, the stock is subject to increased vulnerability from impacts associated with any of these factors. For instance, increased Steller sea lion populations could be applying increased predation pressure to the stock. Crabs were observed in the subtidal video of Sawmill Cove, and Berners Bay is a popular area for harvesting king crabs. Any of the human-associated activities described above could cause disturbance to spawning or rearing crab.

The Slate Cove Ferry Terminal is approximately over 2,000 feet from the mouth of Slate Creek and the Sawmill Cove terminal is over a mile from Sawmill Creek. Due to these distances, the maintenance and operation of the ferry terminals would not impact these andromous streams. Typical breasting dolphins used for ferry terminals allow for free passage of fish. Neither the ferry terminal building/parking areas nor the ferry terminals themselves would impede fish movements to and from Slate Creek, Sawmill Creek, or within Berners Bay.

The ferries used under Alternative 2A would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo tertiary treatment. Solids would be separated from liquids and the sludge would be disposed of at an appropriate sewage treatment plant. Liquids would undergo aeration and disinfection with ultraviolet light. The treated wastewater would be discharged under an NPDES General Permit (#AKG-57-1000) that would be certified by the ADEC. The ADEC could require that a mixing zone be established if needed to meet AWQS. The location of outfall lines from ferry terminals would be identified after design, during permitting. For this reason, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal, including Berners Bay.

5.3.3 Summary of Alternative 2A Impacts

Overall, this alternative includes the construction of about 59 miles of highway (Echo Cove to Sawmill Cove, about 6 miles; Slate Cove to Skagway, about 53 miles), one multi-span bridge, and three ferry terminals. Approximately 35 acres of intertidal/subtidal habitat would be buried or otherwise impacted under the alternative (21.9 acres for the highway construction, 8.8 acres at the Katzehin Ferry Terminal, about 1.1 acre at Slate Cove, and 3.2 acres at Sawmill Cove).

The three new ferry terminals constructed under this alternative would be located at Sawmill Cove, Slate Cove, and north of the Katzehin River. No effects on anadromous EFH would be expected at any of the terminal sites due to their distances from anadromous streams. While the Slate Cove Ferry Terminal is situated over 2,000 feet south of an anadromous stream (Slate Creek), in-water construction windows would be established if necessary to protect anadromous and marine species. The effects of dredging and placement of fill during terminal construction would cause short-term impacts to water quality by increasing sediment suspension in the water column, resulting in degradation of marine habitat; however, BMPs would be followed to limit turbidity increases during construction. All fish and crab species present during construction would likely experience short-term disturbance from noise and vibrations during dredging and pile driving, but an appropriate method of for pile driving will be used depending on which species are present during construction.

Effects on marine EFH from highway construction may also occur due to placement of fill or disposal of materials during sidecasting, which would bury all intertidal and subtidal organisms at the specific in-water fill locations and would destroy or otherwise impact about 26 acres of subtidal and intertidal EFH. Although the intertidal species are opportunistic, recolonization could be affected due to changes in the available substrate, thereby reducing its value as foraging habitat for EFH and crab species. Temporary barge landing sites required to access construction camps would be demobilized and restored as much as possible to the pre-disturbed state. The effects of in-water fill on intertidal and subtidal zones due to highway construction depends on the use of the individual locations by EFH and crab species. For example, areas affected by sidecasting of materials would be less likely to be used by EFH species.

Maintenance and operations of highways can impact water quality, but studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2A would not be large enough for runoff from the highway to cause the exceedance of any AWQSs in receiving waters. Therefore, highway operations under this alternative would not cause impacts to water quality or degradation of anadromous and marine EFH.

The Sawmill Cove Ferry Terminal would impact less than two percent of the spawning area for Pacific herring. Because the principal remaining spawning habitat for the depressed Pacific herring stock in Lynn Canal is located in Berners Bay surrounding the proposed terminal site and the proposed site contains herring spawning habitat, this would be an impact to herring. Various hypotheses have been made about why the stocks have declined, although none have been substantiated by scientific analysis. These hypotheses include one or a combination of the following factors: overfishing, increased predator populations, disease, habitat alteration/degradation, water pollution, and unfavorable oceanographic conditions. Because the herring stock in Lynn Canal is depressed, the stock is subject to increased vulnerability from impacts associated with any of these factors. For instance, increased Steller sea lion populations could be applying increased predation pressure to the stock. At all three terminals, the opportunistic intertidal and subtidal species would likely recolonize slopes of fill areas.

The ferries used under Alternative 2A would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo teritary treatment. Solids would be separated from liquids and the sludge would be disposed of at an appropriate sewage treatment plant. Liquids would undergo aeration and disinfection with ultraviolet light. The treated wastewater would be discharged under an NPDES permit and would meet EPA-established waste discharge limitations. For this reason, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal, including Berners Bay.

Alternative 2A would result in improved access to the east side of Lynn Canal. This is likely to result in increased recreational fishing for anadromous fish along the eastern shoreline of Lynn Canal, as well as the anadromous streams crossed by the alignment. No boat ramps would be constructed along the highway for this alternative. Therefore, they would not increase the number of access points in the project study area for boats other than small, highly portable recreational craft such as kayaks and canoes.

As discussed in Section 4.4.2 of the *Indirect and Cumulative Effects Technical Report*, Alternative 2A is projected to result in an increase in non-resident visitors and a small population increase in Juneau, Haines, and Skagway. This would increase the volume of effluent discharged from the wastewater treatment facilities in these communities. This increase would not reduce water quality in the receiving waters because these facilities must meet NPDES discharge limitations protective of aquatic life.

5.4 Alternative 2B – East Lynn Canal Highway to Katzehin with Shuttles to Haines and Skagway

Alternative 2B would construct a 50.5-mile two-lane highway from the end of Glacier Highway at Echo Cove around Berners Bay and along the eastern coast of Lynn Canal to a point north of the Katzehin River delta. This alternative differs from Alternative 2 is that the highway would end at the Katzehin Terminal north of the Katzehin River delta, instead of continuing on to Skagway. The type of terminal planned for the Katzehin site would be the same as described above for Alternative 2. The highway would cross the same nine anadromous streams as Alternative 2, and three multi-span bridges with in-stream piers and six single-span bridges without in-stream piers would be constructed to cross these streams. Shuttle ferry service to both Skagway and Haines would be provided from a new terminal at Katzehin. The Haines to Skagway shuttle service would continue to operate, with two new shuttle ferries and the *M/V Aurora* forming a three-vessel system. Mainline AMHS service would end at Auke Bay and the *M/V Fairweather* would no longer operate in Lynn Canal.

5.4.1 Construction Impacts

5.4.1.1 Effects of Highway Construction

Highway construction impacts from Alternative 2B that could affect marine and anadromous EFH would stem from: placing clean fill material into intertidal and subtidal areas; constructing temporary barge landing sites (to access upland construction field camps); runoff flowing from construction activities; and installing support piles and falsework (falsework may not be required in all instances) in anadromous streams for multi-span bridge construction that require in-stream piers. Sidecasting of materials directly into intertidal and subtidal areas would not be expected under this alternative because all typical sidecast locations are located north of the Katzehin Ferry Terminal site. Highway and bridge construction impacts are discussed separately.

Highway – As with Alternative 2, the majority of the sites visited during the 2003 intertidal field study along the alignment for Alternative 2B consisted of beaches with varying combinations of boulder, cobble, gravel, sand, and/or mud substrates. Section 4.2.2 describes the intertidal and subtidal conditions at sites likely to be impacted by in-water fill placement. Beach types ranged from gravel/sand beaches in protected cove areas to steep boulder beaches exposed to potentially significant wave actions. Small fish such as crescent gunnels *(Pholis laeta*) and sculpins were observed in tidal pools at many of the protected sites. Crab carcasses were observed at several sites and unidentified crabs were observed at three subtidal locations. The more protected sites could be used by sculpins and crabs for spawning, rearing, and/or growth to maturity. The more exposed, steep boulder beaches are less likely to serve as spawning or rearing areas for the species considered in this assessment.

Subtidal fill sites investigated along the Alternative 2B highway alignment were found to support vegetation (algae), ranging in amounts from sparse to over 25% (STN 1 through 5), but no eelgrass beds or areas of stalked kelp were noted. Unidentified fish were observed at most every site. Subtidal vegetation density of between 25 and 75% is common and was noted at sites A1, A2, and STN 1.

Placement of fill during highway construction may temporarily impact local watersheds by increasing sediment suspension in runoff to neighboring streams and nearshore areas. Intertidal herring spawning habitat in Berners Bay would not be directly affected by highway construction because in-water fill is not a component of this alternative in herring spawning grounds (See Attachment C). To minimize suspended sediments, fill would be placed from the landward side outward during construction, avoiding in-water use of construction equipment. In addition, an ESCP developed by DOT&PF, as well as construction BMPs and the use of silt fences, would minimize impacts from construction runoff that could cause short-term impacts to water quality, thereby degrading marine EFH. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

As described for Alternative 2, temporary barge landing areas would be required to access upland camps along the alignment south of Taiya Inlet. They would be sited to avoid high use areas for fish, and the effects on EFH would be short-term because the sites would be rehabilitated to acceptable standards at the end of the construction project.

Stream Crossing Structures – As described for Alternative 2, stream crossings for highway construction under Alternative 2B would involve construction of single-span bridges without in-stream piers or multi-span bridges with in-stream piers over anadromous streams. Typical construction techniques for multi-span structures include the erection of falsework (falsework may not be required in all instances) to provide a platform for equipment, thereby eliminating the need for equipment to be active in the river bottom. When sensitive receptors are expected to be in the area, vibratory equipment would be used to drive the support piles. If no sensitive receptors such as migrating salmon or eulachon are expected, a percussion method would be used.

Single-span bridges do not encroach upon the stream banks and require minimal modification of the stream profile. Construction activities would be staged from the bridge abutments, and construction equipment would not be used within the anadromous fish streams. In-stream construction is generally restricted to the period from mid-June through mid-August. There would be short-term increases in turbidity during construction of all three multi-span bridges. It is not expected that the increases in turbidity would be noticeable during the summer relative to the ambient turbidity in the Antler, Berners/Lace, and Katzehin rivers. As described for Alternative 2, if high summer water flows prevent in-stream construction, the OHMP may permit in-stream work for the winter months, but, only if the overall construction impacts were deemed to be less than if the work were to occur during the summer. For any construction window, BMPs would be specified to control turbidity during bridge construction. As mentioned for Alternative 2, in-stream construction windows would be implemented to avoid sensitive life stages of salmon and other species.

Large and historic eulachon spawning runs have occurred in and around the Antler and Berners/Lace rivers. To help minimize effects due to construction of the multi-span bridges, the bridge crossings would be located above the sand flats where pre-spawning adult eulachon aggregate. As mentioned above, in-water construction windows would be implemented to reduce impacts on the species' sensitive life stages. Once in place, the multi-span bridge piers, which would be placed approximately 120 feet apart, would not impede fish movement within these three rivers.

5.4.1.2 Effects of Ferry Terminal Construction

Ferry terminal construction impacts from Alternative 2B that could affect marine and anadromous EFH would stem from: excavating, placing clean fill material in the intertidal and subtidal areas for the ferry terminal/parking area and possible breakwater structure, installing piers or piles for the ferry dock, and dredging.

Intertidal site EIT 11 is located near the proposed terminal site north of the Katzehin River (see Section 4.2.1.3) and consists of a steep boulder beach, transitioning to a less steep cobble beach. The subtidal survey of the area found two distinct environments: a boulder-cobble-gravel substrate in the upper subtidal/lower intertidal zone and a muddy substrate in the lower subtidal zone. Vegetation was observed in the more shallow areas, but not in deeper subtidal areas. Due to the steepness of the beach, potential wave exposure, and lack of subtidal vegetation, this site is considered less productive as EFH for use by EFH species and crab species than more protected coves.

Three layouts for the Katzehin Ferry Terminal were evaluated (DOT&PF, 2003b), with Layout #2 chosen as the preferred design due to its enhanced weather protection while balancing costs and environmental impact. Layout #2 includes rubble mound breakwater structures sited to the north and south of a dredged mooring basin. A vehicle transfer bridge supported by a float would be used for berthing/loading the vessel. The breakwaters would provide suitable protection from the predominant northerly and southerly waves; however, exposure to the west would still be evident.

Construction fill would be placed from the landward side outward, avoiding in-water use of construction equipment. The driving of breasting dolphins for the ferry terminal would likely be staged on a floating barge, as would dredging. Dredged materials would get priority for fill material, but excess dredged may need to be disposed according to applicable regulations. Additional placement of in-water fill is required for the ferry terminal building/parking area, which would bury all intertidal and subtidal organisms present at the in-water fill locations.

EFH species and crab species potentially present in the vicinity would likely experience short-term disturbance from noise and vibrations during dredging and pile driving, as described above. Also as mentioned in Section 5.2.1.1, due to the low productivity potential of the

Katzehin site as EFH, and the opportunistic nature of the EFH species and crab species observed during the 2003 field surveys, the effects of terminal construction on EFH are expected to be minimal.

There would be no effects on anadromous EFH due to the distance between the Katzehin Ferry Terminal and the Katzehin River and other anadromous streams. Eulachon at any life history stage would not be affected by habitat alterations associated with ferry terminal construction activities because they are not expected to use the nearshore areas at the Katzehin Ferry Terminal site (see Attachment C).

The effects of dredging and placement of fill during terminal construction would cause short-term impacts to water quality by increasing sediment suspension in the water column, resulting in degradation of marine habitat. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

5.4.2 Long-Term Impacts

5.4.2.1 Effects of Highway Fill

Habitat types potentially affected include sediment beaches (EIT 11, EIT 13, EIT 14, EIT 20, EIT 21, EIT 35, EIT 36, and EIT 37), bedrock cliffs (EIT 18 and 19), and sites where beaches and cliffs are both present (EIT 22 through EIT 26, and EIT 28). One additional site (EIT 12) is a wetland/slough location. The placement of fill would eliminate existing EFH in these areas. Approximately 21.9 acres of intertidal/subtidal habitat would be buried or otherwise impacted by construction of the highway. As described for Alternative 2, intertidal and subtidal species observed in the 2003 field surveys are opportunistic would likely recolonize these areas, but because the amount and character of the area available for recolonization would be different from the undisturbed intertidal zone, the area's value as foraging habitat for EFH and crab species would be reduced. Therefore, depending on the individual area's use by EFH and crab species for spawning, rearing, and/or growth to maturity, and its ability to recolonize, the direct effects on marine EFH of placing in-water fill in specific intertidal and subtidal zones would be realized throughout the 26 acres. However, relative to the total available EFH in Lynn Canal, this fill would not affect regional populations of fish or invertebrate species or the overall quality of available EFH.

5.4.2.2 Effects of Highway Maintenance and Operations

Although maintenance and operations of highways can impact water quality by introducing contaminants to area waters through rainfall and snowmelt runoff, studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2B would not be large enough for runoff from the highway to cause the exceedance of any AWQSs in receiving waters. Therefore, highway operations under this alternative would not likely lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species.

Historic and current Pacific herring spawning habitat is found in Berners Bay. As described for Alternative 2, less than 10% of the highway approaches within 200 feet of the shoreline and spawning habitats along the Berners Bay Flats (see Attachment C), and the remainder is generally located beyond 500 feet from the shoreline. Although elevated turbidity has the potential to suffocate Pacific herring eggs, a vegetated buffer 200 feet wide would serve to filter out pollutants and moderate effects of erosion. Therefore, runoff or disturbance associated with normal highway operations would not reach or substantially alter shoreline habitats in Berners Bay near known herring spawning areas.

5.4.2.3 Effects of Ferry Terminal Dredge and Fill

This alternative discontinues the No Action Alternative mainline and *FVF Fairweather* service in Lynn Canal, but includes a shuttle ferry between Katzehin and Haines. Approximately 4.3 acres of intertidal sediment beach and subtidal area at the Katzehin Ferry Terminal location would be buried with fill and would no longer be available for colonization, and 4.5 acres of subtidal boulder/cobble/gravel habitat would be affected by dredging for the new terminal (DOT&PF, 2003b). As mentioned above under highways, the slopes of fill areas could be colonized by similar intertidal and subtidal species over a few seasons, but the value of the new substrate as foraging habitat for EFH and crab species would be reduced. Breakwater structures could influence local hydrology by changing the flow of water over adjacent substrates, and causing scouring, changes in bathymetry and flushing rates, and alteration of sediment transport (Nightingale and Simenstad, 2001). However, due to the low productivity potential of the Katzehin site as EFH, and the opportunistic nature of the EFH and crab species observed during the 2003 field surveys no EFH or commercially fish or crab species are expected to be affected (see Appendix C).

5.4.2.4 Effects of Ferry Terminal Maintenance and Operations

The ferries used under Alternative 2B would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo the same treatment mentioned under other alternatives: solids would be separated from liquids, liquids would receive tertiary treatment, and the sludge would be disposed of at an appropriate sewage treatment plant. The treated wastewater would be discharged under an NPDES General Permit (#AKG-57-1000) that would be certified by the ADEC. The ADEC could require a mixing zone if necessary to meet AWQS. The location of outfall lines from ferry terminals will be identified after design, during permitting. For these reasons, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal.

5.4.3 Summary of Alternative 2B Impacts

Overall, this alternative includes the construction of about 50 miles of highway, three multi-span bridges with in-stream piers, six single-span bridges without in-stream piers, and one ferry terminal. Approximately 30.7 acres of intertidal/subtidal habitat would be buried or otherwise impacted under the alternative (21.9 acres for the highway construction and 8.8 acres at the Katzehin Ferry Terminal). In contrast to Alternative 2, for Alternative 2B, there would be no effects from sidecasting or fill placement in Taiya Inlet, north of the Katzehin River.

Effects on marine EFH from highway construction would occur due to the placement of fill which would bury all intertidal and subtidal organisms at the specific fill locations. These opportunistic species could recolonize the area, but the value of the new substrate as foraging habitat for EFH and crab species may be reduced. Intertidal herring spawning habitat in Berners Bay would not be directly affected by highway construction because in-water fill in herring spawning grounds is not a component of this alternative (See Attachment C). Temporary barge landing sites required to access construction camps would be demobilized and restored to acceptable standards.

The ferry terminal basin and building/parking area construction activities at the Katzehin location would have effects on intertidal sediment beaches and subtidal mud bottom habitat marine EFH, but not on the site's sparse subtidal vegetation. No effects on anadromous EFH would be expected at the Katzehin terminal site due to its distance from the Katzehin River or other anadromous streams. In addition, in-water construction windows would be established if necessary to protect anadromous and marine species.

Short-term turbidity increases are expected during construction of all three multi-span bridges however, it is not expected that the increases would be noticeable against the ambient turbidity produced by the Antler, Berners/Lace rivers, and Katzehin rivers, and BMPs would be required to reduce the incidence of turbidity during construction. Construction of single-span bridges at all other anadromous fish streams is not expected to increase turbidity.

Studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2B would not be large enough for runoff from the highway to cause the exceedance of any AWQS in receiving waters. Therefore, highway maintenance and operations under this alternative would not likely lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species

The ferries used under Alternative 2B would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo tertiary treatment, with the sludge being disposed of at an appropriate sewage treatment plant, and treated wastewater being discharged to Lynn Canal under an NPDES permit, meeting EPA-established waste discharge limitations. Therefore, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal, including Berners Bay.

In addition to the water quality impacts, proposed marine ferry terminals have some potential to affect local hydrology and wave energy, which may in turn affect flushing rates that affect herring egg development in known shallow water spawning habitats in Sawmill Cove (see Attachment C).

Alternative 2B would result in improved access to the east side of Lynn Canal. This is likely to result in increased recreational fishing for anadromous fish along the eastern shoreline of Lynn Canal, as well as the anadromous streams crossed by the alignment. No boat ramps would be constructed along the highway for this alternative. Therefore, they would not increase the number of access points in the project study area for boats other than small, highly portable recreational craft such as kayaks and canoes.

As discussed in Section 4.4.2 of the *Indirect and Cumulative Effects Technical Report*, Alternative 2B is projected to result in an increase in non-resident visitors and a small population increase in Juneau, Haines, and Skagway. This would increase the volume of effluent discharged from the wastewater treatment facilities in these communities. This increase would not reduce water quality in the receiving waters because these facilities must meet NPDES discharge limitations protective of aquatic life.

5.5 Alternative 2C – East Lynn Canal Highway with Haines/Skagway Shuttle

Alternative 2C would construct a 68.5-mile two-lane highway from the end of Glacier Highway at Echo Cove around Berners Bay and along the eastern coast of Lynn Canal and Taiya Inlet to Skagway with the same design features as Alternative 2. The highway would cross the same nine anadromous streams as Alternative 2, requiring the construction of three multi-span bridges with in-stream piers and six single-span bridges without in-stream piers. The *M/V Aurora* would continue to provide service between Haines and Skagway. The difference between this alternative and Alternative 2 is that a new ferry terminal would be not be built north of the Katzehin River delta. Mainline ferry service would end at Auke Bay, and the *M/V Fairweather* would no longer operate in Lynn Canal.

5.5.1 Construction Impacts

5.5.1.1 Effects of Highway Construction

Highway construction impacts from Alternative 2C that could affect marine and anadromous EFH would stem from: blasting; excavating; placing clean fill material, and depositing materials from sidecasting into intertidal and subtidal areas; constructing temporary barge landing sites (to access upland construction field camps); runoff flowing from construction activities; and installing support piles and falsework (falsework may not be required in all instances) in anadromous streams for multi-span bridge construction. Highway and bridge construction impacts are discussed separately.

Highway – The majority of the sites visited during the 2003 intertidal field study along the alignment for Alternative 2C, consisted of beaches with varying combinations of boulder, cobble, gravel, sand, and/or mud substrates. Beach types ranged from gravel/sand beaches in protected cove areas to steep boulder beaches exposed to potentially significant wave actions. Small fish such as crescent gunnels *(Pholis laeta*) and sculpins were observed in tidal pools at many of the protected sites. Crab carcasses were observed at several sites and unidentified crabs were observed at three subtidal locations. The more protected sites could be used by sculpins and crabs for spawning, rearing, and/or growth to maturity. The more exposed, steep boulder beaches are less likely to serve as spawning or rearing areas for the species considered in this assessment.

Subtidal fill/sidecasting sites investigated along the Alternative 2C highway alignment were found to support vegetation (algae), ranging in amounts from sparse to over 25% (STN 1 through 5, and T4-1), but no eelgrass beds or areas of stalked kelp were noted. Unidentified fish were observed at most every site, and shrimp were noted at several of the Taiya Inlet sites. Subtidal vegetation density of between 25 and 75% is common and was noted at sites A1, A2, and STN 1.

Section 4.2.2 describes the intertidal and subtidal conditions at sites likely to be impacted by in-water fill placement. As described for Alternative 2, the 2003 intertidal survey sites EIT 4, EIT 5, and EIT 9 (see Figure 3-1 and Figure B-1 in Attachment B) are representative of intertidal areas likely to be within a sidecasting area in Taiya Inlet (Table 3-7). As described in Alternative 2, the substrate and habitat at sites EIT 4 and EIT 5 is expected to be similar to areas along Taiya Inlet that could be impacted by sidecasting, although they are not within the current alignment. These sites are composed of bedrock cliffs or vertical faces and exhibit typical intertidal zonation with various narrow band combinations of *Fucus*, mussels, barnacles, and *Verrucaria*.

The 2003 subtidal survey sites STN 12 and STN 13, STN 11, and T3-1 are representative of subtidal areas where sidecasting may occur during highway construction in Taiya Inlet (Figure 3-1 and Table 4-1). These sites have variable subtidal substrates, generally comprised of bedrock in the shallow subtidal, changing to veneers of mud to rock and/or gravel in the deeper areas. Shrimp were observed at all three of the subtidal sites and three unidentified fish were observed at sites STN 12 and STN 13. While these intertidal and subtidal sites may support prey organisms for species being considered in this assessment, they are not likely to serve as refuge or areas important for the spawning, breeding, or growth to maturity of the EFH species.

The intertidal areas along Taiya Inlet are typically narrow and steep, and much of the sidecast material would pass by them and settle in the adjacent subtidal zone. The sidecasting would be dispersed unevenly over a broad area along the shore down steep slopes, and would not produce substantially different habitat than already exists except where the bottom consists of mud. Sidecasting would create a sediment plume that could smother benthic organisms in an area outside the principal zone of deposition, but it would not occur in intertidal or subtidal areas that would likely serve as refuge or areas identified as important to EFH species. For these reasons, effects on EFH due to sidecasting of materials in intertidal areas would not be measurable.

The spawning location for Pacific herring in Lynn Canal has changed considerably over the past several decades, and is now centered between Point Bridget and the Berners Bay flats, with limited spawning in Auke Bay (see Attachment C). Under Alternative 2C, intertidal herring spawning habitat in Berners Bay would not be affected by highway construction because in-water fill is not a component of this alternative in herring spawning grounds (See Attachment C). As described for Alternative 2, the barge landing areas would be temporary, would be sited to avoid high use areas for fish, and the effects on EFH would be short-term because the sites would be rehabilitated to acceptable standards at the end of the construction project.

In addition to the EFH species discussed above, crabs could be present in nearshore areas. In late winter, adult red king crab return to nearshore areas; young-of-the year red and blue king crab require nearshore shallow habitat with protective cover. Early juvenile bairdi Tanner crab also occupy shallow waters and mud habitat. Should any of these species be present in the vicinity of shoreline disturbance during highway construction, it could impact their habitat and survival.

In order to allow access to upland construction field camp, temporary barge landing sites would be necessary along the Alternative 2C highway alignment south of Taiya Inlet. These sites would be identified during highway design, and would utilize existing access locations, previously disturbed areas, and highway fill locations where practicable. At the conclusion of construction, or at the point when the landing sites are no longer needed, the sites would be demobilized, and the original beach material and grade would be restored and revegetated as applicable. Impacts to the intertidal zone and EFH would occur, but all sites would be rehabilitated to acceptable standards.

Blasting, excavating, and placing fill during highway construction may temporarily impact local watersheds by increasing sediment suspension in runoff to neighboring streams and nearshore areas. However, an ESCP developed for the project, as well as construction BMPs and the use of silt fences, would minimize impacts from construction runoff that could cause short-term impacts to water quality, thereby degrading marine EFH. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

Stream Crossing Structures – Multi-span bridges with piers within the rivers would be used for the Antler, Lace, and Katzehin rivers and single-span bridges constructed without in-stream piers would be built for the remaining anadromous streams. Typical construction techniques for multi-span structures include the erection of falsework (falsework may not be required in all instances) to provide a platform for equipment, thereby eliminating the need for equipment to be active in the river bottom. When sensitive receptors, such as migrating salmon or eulachon, are expected to be in the area, vibratory equipment would be used to drive the support piles. If no sensitive receptors were expected, a percussion method would be used.

Single-span bridges do not encroach upon the stream banks and require minimal modification of the stream profile. Construction activities would be staged from the bridge abutments, and construction equipment would not be used within the anadromous fish streams. There would be short-term increases in turbidity during construction of all three multi-span bridges. It is not expected that the increases in turbidity would be noticeable during the summer relative to the ambient turbidity in the Antler, Berners/Lace, and Katzehin rivers. As described for Alternative 2, if high summer water flows prevent in-stream construction, the OHMP may permit in-stream work for the winter months, but, only if the overall construction impacts were deemed to be less than if the work were to occur during the summer. For any construction window, BMPs would be specified to control turbidity during bridge construction. As mentioned for Alternative 2, in-stream construction windows would be implemented to avoid sensitive life stages of salmon and other species.

Tidal channels with small, unidentified fish were observed during the 2003 field survey near the Katzehin River crossing EIT 13; (see Figure B-4 in Attachment B). As described for Alternative 2, short-term effects (e.g., noise and vibration) could influence migratory behavior and spawning success of adult fish, and the development of their eggs (e.g., eulachon) if construction occurred during spawning runs or sensitive life stages of anadromous fish. To minimize this effect, in-water construction windows would be implemented to minimize impacts during sensitive life stages of the fish, and it is expected that fish could avoid the disturbance by moving to one of the numerous tidal channels at the river where the construction is not occurring, because not all tidal channels would be impacted at the same time (i.e., bridge construction would either occur from one side of the river to the other or both sides to the middle).

Because large and historic eulachon spawning runs have occurred in and around the Antler and Berners/Lace rivers, the multi-span bridges crossing these rivers would be located above the sand flats where pre-spawning adult eulachon aggregate. As mentioned above, in-water construction windows would be implemented to reduce impacts on the species' sensitive life stages. Once in place, the multi-span bridge piers, which would be placed approximately 120 feet apart, would not impede fish movement within these three rivers.

5.5.2 Long-Term Impacts

5.5.2.1 Effects of Highway Fill

The area of intertidal/subtidal area filled for highway construction under Alternative 2C would equal 21.9 acres. Habitat types potentially affected include sediment beaches (EIT 6, EIT 9, EIT 11, EIT 13, EIT 14, EIT 20, EIT 21, EIT 35, EIT 36, and EIT 37), bedrock cliffs (EIT 18 and 19), and sites where beaches and cliffs are both present (EIT 22 through EIT 26, and EIT 28). One additional site (EIT 12) is a wetland/slough location. The placement of fill would eliminate existing EFH in these areas. Although the intertidal and subtidal species observed in the 2003 field surveys are opportunistic, recolonization would be affected due to changes in the available substrate, thereby reducing its value as foraging habitat for EFH and crab species. Therefore, depending on the individual area's use by EFH and crab species for spawning, rearing, and/or growth to maturity (protected coves are likely to be used more as compared to exposed steep boulder beaches), and its ability to recolonize, the direct effects on marine EFH of placing in-water fill in specific intertidal and subtidal zones would be realized throughout the 26 acres. However, relative to the total available EFH in Lynn Canal, this fill would not affect regional populations of fish or invertebrate species or the overall quality of available EFH.

5.5.2.2 Effects of Highway Maintenance and Operations

Studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2C would not be large enough for runoff from maintenance and operations of the highway to cause the exceedance of any AWQS in receiving waters. Therefore, highway operations under this alternative would not likely lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species.

Historic and current Pacific herring spawning habitat is found in Berners Bay. Less than 10% of the highway approaches within 200 feet of the shoreline and spawning habitats along the Berners Bay Flats (see Attachment C), and the remainder is generally located beyond 500 feet from the shoreline. Although elevated turbidity has the potential to suffocate Pacific herring eggs, a vegetated buffer 200 feet wide would serve to filter out pollutants and moderate effects of erosion. Therefore, runoff or disturbance associated with normal highway operations would not be expected to reach or substantially alter shoreline habitats in Berners Bay near known herring spawning areas.

5.5.2.3 Effects of Ferry Terminal and Vessel Maintenance and Operations

This alternative discontinues the Alternative 1 mainline and *FVF Fairweather* service in Lynn Canal. As described for Alternative 1, the existing shuttle ferry would continue to provide service between Haines and Skagway. Because there is no new ferry terminal construction or new ferry vessel operations route under Alternative 2C, the effects on marine and anadromous EFH from ferry terminal or vessel maintenance and operations would be as described under Alternative 1.

Due to the distance of anadromous streams from the existing ferry terminals at Skagway and Haines, effects of continued ferry terminal activities on anadromous streams would not occur. Due to their habitat distribution and use patterns, it is unlikely that eulachon at any life history stage would be affected other than temporarily by human disturbances typically associated with ferry terminal or vessel operations (see Attachment C).

5.5.3 Summary of Alternative 2C Impacts

Overall, Alternative 2C includes the construction of about 69 miles of highway, three multi span bridges, six single-span bridges, and no ferry terminals. The area of intertidal/subtidal EFH buried or otherwise impacted under the alternative would equal 21.9 acres.

Effects on marine EFH from highway construction would occur due to the presence of fill or disposal of materials during sidecasting. Placement of fill would bury all intertidal and subtidal organisms at the specific fill locations. Although these species are opportunistic, recolonization would be affected due to changes in the available substrate, thereby reducing its value as foraging habitat for EFH and crab species. Intertidal herring spawning habitat in Berners Bay would not be directly affected by highway construction because in-water fill is not a component of this alternative in herring spawning grounds (See Attachment C). Temporary barge landing sites required to access construction camps would be demobilized and restored to acceptable standards.

Multi-span bridges with in-stream piers would be required over the Antler, Berners/Lace rivers, and Katzehin rivers, and single-span bridges without in-stream piers would be used to cross all other anadromous fish streams. There would be short-term increases in turbidity during construction of all three bridges; however, it is not expected that the increases would be noticeable against the ambient turbidity produced by the Antler, Berners/Lace rivers, and Katzehin rivers, and BMPs would be required to reduce the incidence of turbidity during construction.

Studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 2 would not be large enough for runoff from the highway to cause the exceedance of any AWQSs in receiving waters. Therefore, highway maintenance and operations under this alternative would not likely lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species

Alternative 2C would result in improved access to the east side of Lynn Canal. This is likely to result in increased recreational fishing for anadromous fish along the eastern shoreline of Lynn Canal, as well as the anadromous streams crossed by the alignment. No boat ramps would be constructed along the highway for this alternative. Therefore, they would not increase the number of access points in the project study area for boats other than small, highly portable recreational craft such as kayaks and canoes.

As discussed in Section 4.4.2 of the *Indirect and Cumulative Effects Technical Report*, Alternative 2C is projected to result in an increase in non-resident visitors and a small population increase in Juneau, Haines, and Skagway. This would increase the volume of effluent discharged from the wastewater treatment facilities in these communities. This increase would not reduce water quality in the receiving waters because these facilities must meet NPDES discharge limitations protective of aquatic life.

5.6 Alternative 3 – West Lynn Canal Highway

Alternative 3 would extend Glacier Highway with a two-lane highway 5.2 miles from Echo Cove to Sawmill Cove. Ferry terminals would be constructed at Sawmill Cove and William Henry Bay, and shuttle ferries would operate between the two terminals. A 38.9-mile two-lane highway would be constructed from William Henry Bay to Haines with a bridge across the Chilkat River/Inlet connecting to Mud Bay Road. The highway would cross 11 identified anadromous streams: one on the east side of Lynn Canal (Sawmill Creek), and the remaining 10 on the west side: William Henry Creek, an unnamed stream north of the bay, Endicott River, three unnamed streams north of the Endicott River, Sullivan River, Sullivan Creek, an unnamed creek north of Glacier Point, and the Chilkat River (see the *Anadromous and Resident Fish Streams Technical Report*). Three of these anadromous rivers, the Endicott, Sullivan, and Chilkat rivers would require multi-span bridges with in-stream piers. Single-span bridges without in-stream piers would cross the remaining identified anadromous fish streams. The *M/V Aurora* would continue to operate as a shuttle between Haines and Skagway. Mainline ferry service would end at Auke Bay, and the *M/V Fairweather* would no longer operate in Lynn Canal.

5.6.1 Construction Impacts

5.6.1.1 Effects of Highway Construction

Highway construction impacts from Alternative 3 that could affect marine and anadromous EFH would stem from: placing clean fill material into intertidal and subtidal areas; constructing temporary barge landing sites (to access upland construction field camps); runoff flowing from construction activities; and installing support piles and falsework (falsework may not be required in all instances) in anadromous streams for multi-span bridge construction. Sidecasting of materials directly into intertidal and subtidal areas would not be expected under this alternative because all typical sidecast locations are located north of the Katzehin Ferry Terminal site. Highway and bridge construction impacts are discussed separately.

Highway – Two locations on the west side of Lynn Canal would require placement of fill for highway construction in the intertidal zone. One is situated approximately halfway between the Endicott and Sullivan rivers, and the other is located immediately north of Pyramid Island, where a causeway would connect the west and east Chilkat River bridges. This causeway would span the mouth of the Chilkat River at a location where the river becomes tidally influenced and is considered a part of the intertidal zone, and is referred to as the Chilkat River/Inlet. The impacts of the placement of fill in these areas would be the loss and/or disturbance of about 4.9 acres of intertidal/subtidal habitat. The placement of fill may temporarily impact local watersheds by increasing sediment suspension in runoff to neighboring streams and nearshore areas. To minimize this effect, fill would be placed from the landward side outward during construction, avoiding in-water use of construction equipment. In addition, an ESCP developed by DOT&PF, as well as construction BMPs and the use of silt fences, would minimize impacts from construction runoff that could cause short-term impacts to water quality, thereby degrading marine EFH. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

Construction of the West Lynn Canal Highway would also require construction camps with associated barge landing areas. The barge landing areas would be temporary, would be sited to avoid high use areas for fish, the effects would be short-term, and the sites would be rehabilitated to acceptable standards at the end of the construction project.

Stream Crossing Structures – The typical bridge construction techniques presented in the Alternative 2 discussion also apply under Alternative 3. Although the Chilkat River/Inlet is the widest (11,000 feet) of all bridges for any of the project alternatives, the only difference in bridge construction technique would be the placement of in-water fill for the bridge approaches. When anadromous fish (such as eulachon which use the lower 12 km of the river) are expected to be in the area, vibratory equipment would be used to drive the support piles. If no anadromous fish such as migrating salmon or eulachon are expected, a percussion method would be used.

During multi-span bridge construction, some disturbance is expected to fish in the Endicott and Sullivan rivers and the Chilkat River/Inlet, all of which support spawning populations of eulachon. As described for Alternative 2, short-term effects (e.g., noise and vibration) could influence migratory behavior and spawning success of adult fish, and the development of their eggs (e.g., eulachon) if construction occurred during spawning runs or sensitive life stages of anadromous fish. To minimize this effect, in-water construction windows would be implemented. Once in place, the piers of the multi-span bridges would not impede fish movement within the rivers. There would be short-term impacts to water quality due to increased turbidity during construction; however, it is not expected that the increases would be observable relative to ambient conditions in these rivers during the summer construction season.

In addition to the multi-span bridges (with in-stream piers) over the Chilkat River/Inlet and the Endicott and Sullivan rivers, single-span bridges without in-stream piers would cross the remaining seven anadromous streams. Single-span bridges that do not encroach upon the stream banks require minimal modification of the stream profile. Construction activities would be staged from the bridge abutments and would not occur in the anadromous streams. However, as with multi-span bridges, short-term disturbance due to noise and vibration during construction of the abutments could occur, but effects due to water quality impacts (turbidity) would not.

5.6.1.2 Effects of Ferry Terminal Construction

Two new ferry terminals would be constructed under this alternative: Sawmill Cove and William Henry Bay. The type of terminal planned for Sawmill Cove would consist of a stern load berth facility including two bridge support floats and a shared dolphin system comprised of all-tide floating fenders. Access to the terminal vessels would be via twin 143-foot long steel transfer bridges founded on offshore fill (see the *Marine Terminal Concepts Report*). The terminal planned for William Henry Bay would consist of a 24-foot-by-210-foot pile-supported access trestle (required for vessels to reach adequate water depths for berthing) and a single berth terminal with a transfer bridge accessed by a pile-supported dock structure. The transfer bridge would be raised and lowered by a mechanical counterweight lift system, and fixed dolphin structures would be used to moor the vessels during transfers. Pile driving methods would be as described for anadromous EFH for the access trestle. At present, no dredging is planned for the

William Henry Bay terminal; however, further design at this terminal may include evaluation of potential breakwater alternatives to provide northerly wave protection. In that case, dredging would be required to allow efficient construction of the structure. Fill would be placed in the intertidal area.

Ferry terminal construction impacts from Alternative 3 that could affect marine and anadromous EFH would stem from: excavating, placing of clean fill material in intertidal and subtidal zones for the ferry terminal/parking area and possible breakwater structure, installing piers or piles for the ferry dock, and dredging.

Subtidal surveys at Sawmill Cove observed a seabed comprised almost exclusively of muds, sand, and gravels, although there may be some bedrock outcrops on the seabed in one location. Gravel content was highest in the intertidal zone and dropped off rapidly in the subtidal zone where sands and muds predominated. Vegetation cover was closely linked to the gravel component; therefore cover dropped off rapidly in the offshore. Vegetation included sparse but persistent and evenly distributed large-bladed kelp that is used by Pacific herring for spawning. No eelgrass or stalked kelp was present at the site. The 2003 intertidal surveys of Sawmill Cove observed a gravel cobble beach with rocky outcrops, and little vegetation. Based on a field visit on August 31, 2004, NMFS reported the intertidal vegetation consisted of dense *Fucus*, or rockweed, on the rocky points. In the low intertidal zone, rockweed was interspersed with *Lamanaria saccharina* and *Agarum clathratum* (both large-bladed kelp).

The Sawmill Cove Ferry Terminal site likely supports various life stages of several of the species considered in this assessment, such as sablefish, Pacific herring, and, rarely, skates. The August 2004 NMFS survey recorded a large school of young Pacific herring near the proposed terminal location (personal communication with Susan Walker, NMFS). In the subtidal zone, one location of orange sea pens *(Ptilosarcus gurneyi*) was noted in the northern third of the site (estimated at an area of 21,500 square feet; depth ranging from 50 to 80 feet). These organisms are living marine substrates and are designated as HAPC, which must be protected under the Act. Unidentified crabs were observed in the subtidal video of Sawmill Cove. Berners Bay is a popular area for harvesting king crabs.

William Henry Bay was investigated as part of the 2003 intertidal survey (see Section 4.2.1.4). The intertidal zone at William Henry Bay is a biologically rich and diverse area. The ferry terminal building/parking site consists of a sand, gravel, cobble, and boulder beach changing to boulders towards the north, away from the head of the bay. This site is extensively used for spawning, rearing, and growth to maturity by EFH species. Salmon, sculpins, and other small fish were observed in the intertidal zone, and numerous clumps of fish eggs, likely sculpin eggs, were found in crevices and tidal pools in the lower intertidal zone.

The 2003 subtidal survey at William Henry Bay showed gravel substrate to be limited to the shallow nearshore (less than 6 feet) and intertidal zone. The gravel includes boulders and cobbles along the western shore and mostly gravel and cobbles at the southern part, near the head of the bay. Fine sediments increase rapidly in the offshore direction, with sands and muds extending to a depth of 30 to 45 feet and mud predominating in deeper water. Although minimal vegetation was observed in the subtidal zone, sea cucumbers were very dense at the northern end of the site (0 -10 foot depths), orange sea pens are common in the deeper (30 to 60 feet), northern part of the site, and sea whips were also noted in the deep, northeastern corner (greater than 57-foot depths). As mentioned above for Sawmill Cove, these sea pens and sea whips are organisms classified as living marine substrates and are designated as HAPC, which must be protected under the Act. Unidentified crabs were observed in the subtidal zone. Anemones were common in depths greater than 33 feet. Flatfish are common throughout the site at depths greater than 20 feet.

The in-water bathymetry at William Henry Bay has been well defined by a recent survey (DOT&PF, 2003b). There is ample water depth; however, the beach slope at the proposed site is relatively flat and long. A pile-supported access trestle would be required to reach adequate water depths for vessel berthing. In-water construction windows would be established if determined necessary to protect anadromous and marine species. Placement of the piles would use either vibratory (if sensitive species such as migrating salmon are present) or percussion (if sensitive species are not expected to be present).

Anadromous fish populations have been identified by OHMP at Sawmill Creek (see the *Anadromous and Resident Fish Streams Technical Report*). However, the proposed Sawmill Cove Ferry Terminal is sited over a mile north of the mouth of Sawmill Creek, at a site investigated during the 2003 intertidal survey (see Section 4.1.1.1). Two anadromous streams/rivers flow into William Henry Bay: the Beardslee River and William Henry Creek. The Beardslee River is approximately 3,000 feet southeast (at the head of the bay, not crossed by the highway) and William Henry Creek is approximately 3,000 feet north of the proposed ferry terminal. The Beardslee River provides excellent fish spawning and rearing habitat and supports populations of coho, chum, and pink salmon. William Henry Creek has been cataloged by OHMP for pink and chum salmon.

During construction at both ferry terminal locations, in-water fill would be placed from the landward side outward, avoiding in-water placement of construction equipment. Typically, breasting dolphins for the ferry terminal are driven utilizing equipment staged on a floating barge. There would be short-term increases in turbidity during construction of the Sawmill Cove Ferry Terminal; however, the increases might not be noticeable relative to the ambient turbidity within the Berners Bay area, and BMPs would be followed to limit turbidity increases during construction. This is particularly necessary due to the presence of sea pens (designated as HAPC) in the subtidal zone at the site. It may be necessary to better map the location of the sea pens in order to provide protection for the area during construction.

The proposed William Henry Bay Ferry Terminal site is habitat used for spawning, rearing, and growth to maturity by sculpin and other EFH fish species. There would be short-term increases in turbidity during construction because there are muds in deeper water. The increases would be detectable over ambient conditions in the clear waters of William Henry Bay, particularly during calm conditions. As mentioned for Sawmill Cove, BMPs would be followed to limit turbidity increases during construction, which is particularly necessary due to the presence of sea pens (HAPC) as described above. Fish species would likely experience short-term disturbance from noise and vibrations during pile driving, but this would be minimized to the greatest extent possible by choosing proper construction methods based on the species expected to be present at the time of construction. Thus, effects due to construction activities for the ferry terminal would occur, but they would be short-term.

In addition to the EFH species, crabs are present in William Henry Bay. There are commercial and personal use fisheries for king crab in Lynn Canal, including William Henry Bay. In late winter, adult red king crabs return to nearshore areas. Young-of-the year red and blue king crabs require nearshore shallow habitat with protective cover. Early juvenile bairdi Tanner crab also occupy shallow waters and mud habitat. Should any of these species be present in the bay, disturbance due to terminal construction could impact their habitat and survival.

Due to the spatial separation between the anadromous streams (Sawmill Creek, the Beardslee River, and William Henry Creek) and the proposed terminal locations, there are no expected effects of construction on anadromous fish species.

5.6.2 Long-Term Impacts

5.6.2.1 Effects of Highway Fill

As mentioned in Section 5.6.1.1, two locations on the west side would require placement of fill in the intertidal zone. A total of 0.09 acre of fill would be placed approximately two miles north of the Endicott River. Another location is situated immediately north of Pyramid Island where a 1,200-foot solid-fill causeway covering about 4.8 acres would connect the west and east Chilkat bridges. The 4.8 acres in the Chilkat River/Inlet that would be filled are highly active and depositional and do not support a substantial benthic community. There are no expected effects of highway and/or bridge maintenance and operations on either marine or anadromous EFH because relative to the total available EFH in Lynn Canal, this fill would not affect regional populations of EFH or crab species or the overall quality of available EFH.

5.6.2.2 Effects of Highway Maintenance and Operations

Studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 3 would not be large enough for runoff from maintenance and operations of the highway to cause the exceedance of any AWQSs in receiving waters. Besides, a 200-foot wide vegetated buffer placed between the highway and shoreline would serve to filter out pollutants and moderate effects of erosion. Therefore, highway operations under this alternative would not likely lead to degradation of anadromous and marine EFH or effects on the commercially important EFH species.

5.6.2.3 Effects of Ferry Terminal Dredge and Fill

This alternative would discontinue mainline and FVF *Fairweather* service in Lynn Canal; the Haines/Skagway ferry would still continue under this alternative. In addition, there would be ferry service between Sawmill Cove and William Henry Bay.

For the Sawmill Cove Ferry Terminal, approximately 3.2 acres of intertidal and subtidal habitat would be impacted (1.9 acres of fill and 1.3 acres dredged). The footprint of the Sawmill Cove Ferry Terminal would impact approximately 300 feet (0.06 mile) of shoreline at MLLW, the equivalent of less than two percent of the alongshore herring spawning habitat observed in Berners Bay in 2003 (see Attachment C). Intertidal and subtidal species observed in the 2003 field surveys are opportunistic would likely recolonize these areas, but because the amount and character of the area available for recolonization would be different from the undisturbed intertidal zone, the area's value as foraging habitat for EFH and crab species would be reduced. Therefore, depending on the individual area's use by EFH and crab species for spawning, rearing, and/or growth to maturity, and its ability to recolonize, effects on marine EFH of placing in-water fill in specific intertidal and subtidal zones would occur. Herring eggs and larvae that are present in shallow water spawning habitats and crabs using the shallow subtidal and intertidal zones near Sawmill Cove have some potential for direct displacement, removal, or burial (see Attachment C). The proposed Sawmill Cove ferry terminal is located near the center of the existing spawning habitat for the depressed Lynn Canal Pacific herring in Berners Bay. The habitat in the subtidal area that would be disturbed by filling and dredging for this terminal is suitable for herring spawning. The ferry terminal would impact less than two percent of the spawning area for Pacific herring. Also, as discussed in previous subsections of Section 5.3, there are several factors, which may contribute to the depressed condition of the herring stock, including overfishing, increased predator populations, disease, habitat alteration/degradation, water pollution, and unfavorable oceanographic conditions. Because the herring stock in Lynn Canal is depressed, the stock is subject to increased vulnerability from impacts associated with any of these factors for instance increased Steller sea lion populations could be applying increased predation pressure to the stock.

The William Henry Bay Ferry Terminal would cover 800 feet of shoreline, or about 6 percent of the available shoreline in the bay. The loss of about 4.8 acres total of intertidal and subtidal EFH at the proposed terminal site would have a small impact on EFH and crab species, due to the extensive habitat available in the bay. As described for Alternative 2, recolonization from the surrounding populations may occur on appropriate new substrate, but the amount and character of substrate available for recolonization would differ from the natural habitat. The impacted area at William Henry Bay would increase if construction of a breakwater and/or additional dredging of the area is necessary.

5.6.2.4 Effects of Ferry Terminal Maintenance and Operations

Increased turbidity from vessel operations may be detectable over ambient conditions in the waters adjacent to the terminals, particularly at William Henry Bay during periods of calm weather, but this effect would be short-term. As mentioned above, intertidal and subtidal EFH habitat is extensive in the bay and it is expected that EFH and crab species could avoid the turbidity by temporarily moving to another area.

The ferries used under Alternative 3 would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo tertiary treatment. Solids would be separated from liquids and the sludge would be disposed of at an appropriate sewage treatment plant. Liquids would undergo aeration and disinfection with ultraviolet light. The treated wastewater would be discharged under an NPDES General Permit (#AKG-57-1000) that would be certified by the ADEC. If necessary to meet AWQS, the ADEC could require a mixing zone associated with the outfall. The location of outfall lines from ferry terminals would be identified after design, during permitting. For this reason, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal, including Berners Bay.

Propeller wash disturbances from boat traffic may increase loss of fish eggs found in known shallow water spawning habitats, whereas artificial lighting, noise, vessel traffic, and other human-associated activities near ferry terminals may disrupt natural behaviors (e.g., avoidance or schooling) of larval, juvenile, and adult fish or spawning or rearing crab (see Attachment C). Pacific herring are known to spawn in Berners Bay, particularly in the vicinity of Sawmill Cove. Because their use of the nearshore areas in William Henry Bay is unclear, it is unknown whether eulachon at any life history stage would be affected by human disturbances typically associated with ferry terminal or vessel operations in the bay (see Attachment C).

The William Henry Bay Ferry Terminal site is located approximately 3,000 feet from the mouth of either William Henry Creek or the Beardslee River. The pile-supported trestle and dolphins used for the ferry terminals would allow free passage of fish. Neither the fill placed for the ferry terminal building/parking nor the ferry terminal piers would impede fish movements to and from William Henry Creek or the Beardslee River.

5.6.3 Summary of Alternative 3 Impacts

Overall, this alternative includes the construction of about 39 miles of highway (from William Henry Bay to Mud Bay Road), three multi-span bridges with in-stream piers, 8 single-span bridges without in-stream piers, and two ferry terminals. Approximately 13 acres of intertidal/subtidal habitat would be buried or otherwise impacted under the alternative (4.9 acres for the highway construction, 4.8 acres at the William Henry Bay Ferry Terminal, and 3.2 acres at Sawmill Cove).

Two areas of fill for highway construction have been identified on the west side. The area between the Endicott and Sullivan rivers is not likely to be extensively used for spawning, rearing, and/or growth to maturity by EFH species. The other area is situated north of Pyramid Island in an area of high sediment deposition. While about 5.7 acres of intertidal/subtidal habitat would be lost due to highway construction, neither area would be extensively used by EFH species. As described for Alternative 2, the barge landing areas would be temporary, would be sited to avoid high use areas for fish, the effects would be short-term, and the sites would be rehabilitated to acceptable standards at the end of the construction project.

Two new ferry terminals would be constructed under this alternative: one at Sawmill Cove, and one at William Henry Bay. The loss of Pacific herring habitat at Sawmill Cove would be an EFH impact because of the depressed Pacific herring stock in Lynn Canal. As explained in Section 5.3.3, Summary of Alt. 2A Impacts, several factors are part of the consideration for the depressed stock. While the ferry terminal at William Henry Bay would be built between two cataloged anadromous fish streams, in-water construction windows would protect anadromous and marine species as necessary. No effects are expected on anadromous EFH at the Beardslee River or William Henry Creek due to construction of a ferry terminal in William Henry Bay.

Maintenance and operations of highways can impact water quality, but studies of highway runoff in Alaska indicate that the volume of traffic on the highway under Alternative 3 would not be large enough for runoff from the highway to cause the exceedance of any AWQSs in receiving waters. Therefore, highway operations under this alternative would not cause impacts to water quality or degradation of anadromous and marine EFH.

Marine EFH habitat is extensive in William Henry Bay, and may not be a limiting factor in the spawning, rearing, or growth to maturity of the marine EFH species. Also colonization of fill slopes may occur. While construction of the terminal would remove about 2 acres of intertidal and/or subtidal EFH, this area would increase if the area requires additional dredging or if a breakwater is required. Breakwater structures may influence local hydrology by changing the flow of water over adjacent substrates, causing scouring, changes in bathymetry and flushing rates, and alteration of sediment transport (Nightingale and Simenstad, 2001).

The ferries used under Alternative 3 would have sanitary waste holding tanks or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo tertiary treatment, with the sludge being disposed of at an appropriate sewage treatment plant, and treated wastewater being discharged under an NPDES permit, meeting EPA-established waste discharge limitations. Therefore, the effluent should not impact fish or crab habitat or affect fish and crab populations in Lynn Canal, including Berners Bay.

Alternative 3 would result in improved access to Berners Bay north from Echo Cove to Sawmill Cove and the west side of Lynn Canal. This is likely to result in increased recreational fishing for anadromous fish along the western shoreline of Lynn Canal, as well as the anadromous streams crossed by the alignment. No boat ramps would be constructed along the highway for any of these alternatives. Therefore, they would not increase the number of access points in the project study area for boats other than small, highly portable recreational craft such as kayaks and canoes.

As discussed in Section 4.4.3 of the *Indirect and Cumulative Effects Technical Report*, Alternative 3 is projected to result in an increase in non-resident visitors and a small population increase in Juneau and Haines. This would increase the volume of effluent discharged from the wastewater treatment facilities in these communities. This increase would not reduce water quality in the receiving waters because these facilities must meet NPDES discharge limitations protective of aquatic life.

5.7 Alternatives 4A and 4C – Service from Auke Bay

The impacts of alternatives 4A and 4C are discussed together because both include changes to the ferry service, reconstruction of the west end of the Auke Bay Ferry Terminal to create a double-stern berth, and do not require any new highway construction. In general, the ferry service for both alternatives would involve shuttles between Auke Bay, Haines, and Skagway. The maintenance and operations effects of Alternatives 4A and 4C would be similar to Alternative 1 - No Action Alternative effects, with the addition of the effects due to modifications at the Auke Bay terminal.

5.7.1 Construction Impacts

As described in Section 2.2, one of the new double stern berths would accommodate the two vessels necessary for north Lynn Canal service, while the other twin berth would accommodate future AMHS needs outside of the Lynn Canal Corridor. The double stern berth would consist of twin vehicle transfer bridges supported by steel stern berth floats. Vessels would be moored against a 40-foot by 480 foot mooring float. Reconstruction of the Auke Bay terminal would require the removal and replacement of pilings, and placement of some fill in the bay.

Construction of the new twin berth would occur in Auke Bay, which is already altered by development. Several anadromous streams flow into the bay (Auk Nu Creek: Catalog #111-50-10350, Waydelich Creek: #111-50-10370, Bay Creek: #111-50-10390, and Auke Creek: #111-50-10420). These streams were not surveyed in 1994; however, they are listed in the Catalog (ADF&G, 2003a). Impacts on anadromous habitat could occur because Pacific salmon migrate through the area to nearby streams. As mentioned for Alternative 1, the DOT&PF EFH Assessment indicated that, in addition to the five species of salmon, flounder, pollock, and several species of sole, sculpins, pacific cod, and Pacific herring could use the nearshore area of the Auke Bay terminal project site (DOT&PF 2003a). Various species of crabs could also be present in nearshore areas. In late winter, adult red king crabs return to nearshore areas. Young-of-the year red and blue king crab require nearshore shallow habitat with protective cover. Early juvenile bairdi Tanner crab also occupy shallow waters and mud habitat. It is unclear as to whether eulachon would be present in these nearshore areas (see Attachment C).

All fish and crab species present during construction would likely experience short-term disturbance from noise and vibrations during pile driving. As described previously, the method chosen for pile driving (vibratory or percussion) would depend on the incidence of fish and crab species in the area during construction. There would be short-term increases in turbidity during placement of fill for the Auke Bay Ferry Terminal; however, because the terminal area has already been modified, and BMPs would be followed to limit turbidity increases during construction, it is not expected that effects from turbidity would effect species other than temporarily. Modification or replacement of natural substrates by ferry terminals could inhibit future spawning activities by herring if a larger spawning population were to return to the bay. Fish eggs and larvae that are present in shallow water spawning habitats in Auke Bay have some potential for direct displacement, removal, or burial (see Attachment C).

5.7.2 Long-Term Impacts

5.7.2.1 Effects of Ferry Terminal Dredge and Fill

The placement of fill and pilings in Auke Bay would result in the loss of less than one acre of intertidal and subtidal habitat. This loss would not result in a measurable reduction in any benthic or fish populations in the project region or Auke Bay.

5.7.2.2 Effects of Ferry Terminal Maintenance and Operations

Currently, there is limited Pacific herring spawning in Auke Bay. Any effects from increased ferry vessel operations (transient lighting, increased access, turbidity changes, and potential water quality impacts) could affect natural behaviors (e.g., avoidance or schooling) of larval, juvenile, and adult herring, and/or future herring spawning in the area. Propeller wash disturbances from boat traffic may increase loss of herring eggs found in known shallow water spawning habitats (see Attachment C). Laboratory flume studies on the potential effect of ferry propeller wash on eelgrass from increased current velocities found that velocities above 100 centimeters/second caused significant sediment erosion and extensive damage to eelgrass rhizomes (Hart Crowser, Battelle, and Hartman Associates, 1997). This in turn would impact herring spawning and success, if ferries were to pass by eelgrass beds used by spawning herring.

5.8 Alternatives 4B and 4D – Service From Berners Bay

The impacts of Alternatives 4B and 4D are discussed together because both alternatives involve extending Glacier Highway 5.2 miles from Echo Cove to Sawmill Cove in Berners Bay, including construction of a single-span bridge without in-stream piers over Sawmill Creek, as described for Alternative 2. Both alternatives also include the Auke Bay Ferry Terminal modifications described above for Alternatives 4A and 4C, and construction of a new twin-berth ferry terminal at Sawmill Cove (including about 1.9 acres of intertidal fill and 1.3 acres of subtidal dredging). Under both alternatives, the Haines/Skagway shuttle service would continue but the *M/V Fairweather* would no longer operate in Lynn Canal These alternatives differ from each other only in the type and possibly the frequency of ferry service provided.

5.8.1 Construction Impacts

5.8.1.1 Effects of Highway Construction

Highway construction impacts from Alternatives 4B and 4D that could affect marine and anadromous EFH would stem from flowing runoff from construction activities. Highway and bridge construction impacts are discussed separately.

Highway – The highway construction associated with these alternatives does not require the placement of in-water fill. Construction runoff would cause short-term impacts to water quality, resulting in degradation of marine habitat. Acute but less frequent contributions involving accidental spills of oil, gasoline, and industrial chemicals may also occur during highway construction.

Stream Crossing Structures – Based on data obtained during a field survey in 1994 and updated with information from the Catalog, the highway from Echo Cove to Sawmill Cove would cross one anadromous fish stream, Sawmill Creek. A single span-bridge constructed without in-stream piers would cross the creek. This bridge would not encroach on the stream banks and require minimal modification of the stream profile. Construction activities would be staged from the bridge abutments, and construction equipment would not be used within the anadromous fish streams.

Construction BMP's would limit impacts from stream crossing construction on marine and anadromous EFH. In-stream construction is generally restricted to the period from mid-June through mid-August to avoid sensitive life stages of salmon, and would be timed to avoid other species' sensitive life stages as well.

5.8.1.2 Effects of Ferry Terminal Construction

The type of terminal planned for Sawmill Cove would consist of a stern load berth facility including two bridge support floats and a shared dolphin system comprised of all-tide floating fenders. Access to the terminal vessels would be via twin 143-foot long steel transfer bridges founded on offshore fill (see the *Marine Terminal Concepts Report*). As described above for Alternatives 4A and 4C, reconstruction of the Auke Bay terminal would require the removal and replacement of pilings, and placement of some fill in the bay.

Based on 2003 subtidal surveys, the seabed at the proposed Sawmill Cove terminal site is almost exclusively muds, sand, and gravels, though there may be some bedrock outcrops on the seabed in one location. Gravel content is highest in the intertidal zone and drops off rapidly in the subtidal zone, where sands and muds predominate. Vegetation cover is closely linked to the gravel component; therefore, cover drops off rapidly in the offshore. Vegetation includes sparse but consistent and evenly distributed large-bladed kelp. No eelgrass or stalked kelp was present at the site. However a survey conducted by NMFS in August 2004 recorded sparse but persistent *Lamanaria saccharina* and *Agarum clathratum* (both large-bladed kelps).

The Sawmill Cove Ferry Terminal site likely supports various life stages of several of the species considered in this assessment (e.g., sablefish, Pacific herring, and, rarely, skates). In the subtidal zone, one location of orange sea pens *(Ptilosarcus gurneyi*) was noted in the northern third of the site (estimated at an area of 21,500 square feet; depth ranging from 50 to 80 feet). These organisms are living marine substrates and are designated as HAPC, which must be protected under the Act. Unidentified crabs were observed in the subtidal video of Sawmill Cove. Berners Bay is a popular area for harvesting king crabs.

Anadromous fish populations have been identified by OHMP at Sawmill Creek (see the *Anadromous and Resident Fish Streams Technical Report*). However, the proposed Sawmill Cove Ferry Terminal is sited over a mile north of the mouth of Sawmill Creek, at a site investigated during the 2003 intertidal survey (see Section 4.1.1.1), and therefore, no effects are expected on anadromous EFH at this site.

During construction, in-water fill would be placed from the landward side outward breasting dolphins would typically be driven utilizing equipment staged on a floating barge. Dredging at the Sawmill Cove site would also occur from a barge, and the dredged materials would be used as much as possible as basis for the fill; however, it is likely that some amount of dredged materials would need to be disposed according to applicable regulations. Additional placement of in-water fill is required for the ferry terminal building/parking area at the Sawmill Cove terminal sites; this fill would bury all intertidal and subtidal organisms at the in-water fill locations. Although these species are opportunistic, and the slopes of in-water fill areas could be recolonized, the amount and character of substrate available for recolonization would differ from the natural habitat, thereby reducing its value as foraging habitat for EFH and crab species. Herring eggs and larvae that are present in shallow water spawning habitats and crabs using the shallow subtidal and intertidal zones near Sawmill Cove (in particular) have some potential for direct displacement, removal, or burial (see Attachment C).

All fish and crab species present during construction would likely experience short-term disturbance from noise and vibrations during dredging and pile driving. The method chosen for pile driving (vibratory or percussion) would depend on the incidence of fish and crab species in the area during construction. There would be short-term increases in turbidity during construction; however, the increases might not be noticeable relative to the ambient turbidity within the Berners Bay area, and BMPs would be followed to limit turbidity increases during construction. This is particularly necessary due to the presence of sea pens (designated as HAPC) in the subtidal zone at the site. Pacific herring are known to spawn along the eastern shore of Berners Bay, and the proposed Sawmill Cove Ferry Terminal supports kelp that herring use for spawning. The short-term turbidity mentioned above could result in the loss of some Pacific herring eggs in the vicinity of the Sawmill Cover terminal, but is not expected to have a population effect. At the Auke Bay terminal site, turbidity increase could result in the loss of some benthic organisms. These impacts would not have population-level effects on any benthic species, fish, or crab species in Lynn Canal.

The effects on fish habitat due to construction of the ferry terminals at Sawmill Coves would be short-term. The effects of dredging and placement of fill during terminal construction would cause short-term impacts to water quality by increasing sediment suspension in the water column, resulting in degradation of marine habitat. There exists some potential for contaminants to accumulate in nearshore sediments and affect Pacific herring egg development as well as individual sculpin, juvenile red and blue king crab, and juvenile bairdi Tanner crabs. Proper ferry terminal construction techniques and timing would minimize these indirect effects on Pacific herring and crabs. The impacts to sculpins would be short-term and localized. The discussion of the loss of Pacific herring spawning habitat is provided under the maintenance and operations section, below.

5.8.2 Long-Term Impacts

5.8.2.1 Effects of Highway Fill

Because there is no placement of in-water fill for construction of the highway, there would be no EFH lost due to burial and recolonization issues.

5.8.2.2 Effects of Highway Maintenance and Operations

Stormwater and melt water runoff from the bridge over Sawmill Creek would not alter water quality sufficiently to impact anadromous and marine fish habitat. Studies of highway runoff in Alaska indicate that the volume of traffic on the proposed highway for Alternatives 4B and 4D is not large enough for runoff to cause the exceedance of any AWQSs in receiving waters.

5.8.2.3 Effects of Ferry Terminal Dredge and Fill

Under Alternatives 4B and 4D, approximately 3.2 acres of intertidal/subtidal habitat would be filled or dredged for the Sawmill Cove Ferry Terminal. The impact to 3.2 acres of intertidal and subtidal habitat, the replacement of natural substrates due to terminal construction, and the dredging of approximately 16,000 cubic yards for a mooring basin would alter habitat usage in the disturbed area. Filling would result in the loss of habitat while dredging and ongoing use would substantially reduce habitat value in the dredged areas. The Sawmill Cove Ferry Terminal would cover approximately 300 feet (0.06 mile) of shoreline at MLLW. This is less than 2 percent of the alongshore herring spawning length (approximately 3 miles) observed in Berners Bay in 2003. This habitat loss would impact Pacific herring spawning because the Sawmill Cove site provides spawning habitat for this species.

The Sawmill Cove Ferry Terminal is over a mile from anadromous Sawmill Creek. Typical breasting dolphins used for ferry terminals allow for free passage of fish. Neither the in-water fill for the ferry terminal building/parking areas nor the ferry terminals themselves would impede fish movements to and from Sawmill Creek or within Berners Bay.

5.8.2.4 Effects of Ferry Terminal Maintenance and Operations

Turbidity at the ferry terminal could be increased over ambient conditions for short periods by ferries maneuvering into and out of the terminal. Short-term turbidity increases and propeller scour could cause disturbance to spawning or rearing crab in the vicinity of the terminal, and displace some Pacific herring eggs and larvae in the immediate vicinity of the Sawmill Cove Ferry Terminal.

There is the potential for accidental fuel spills from ferries at terminals and while traveling Lynn Canal routes. To date, no in-water fuel spills have been associated with AMHS operations in Lynn Canal. The effects of a spill would depend on its size and location.

The fast vehicle ferry and conventional monohull shuttle that would be used for Alternative 4B and 4D, respectively, would have sanitary waste holding tanks, or would discharge treated wastewater meeting applicable standards. Sanitary waste generated at the ferry terminals would undergo tertiary treatment. Solids would be separated from liquids and the sludge would be disposed of at an appropriate sewage treatment plant. Liquids would undergo treatment and disinfection with ultraviolet light. The treated wastewater would be discharged under an NPDES General Permit (#AKG-57-1000) that would be certified by ADEC. If necessary to meet AWQS, ADEC could require that a mixing zone be established. For this reason, the effluent should not impact fish habitat or affect fish populations in Lynn Canal, including Berners Bay.

5.8.3 Summary of Alternatives 4B and 4D Impacts

The construction of Alternatives 4B and 4D would result in the direct loss of 3.2 acres of EFH as a result of filling and dredging for the Sawmill Cove Ferry Terminal. This is historically documented spawning habitat for Lynn Canal Pacific herring stock (see Attachment C). Ferry maneuvers at Sawmill Cove could increase turbidity in the vicinity of the terminal sufficiently to impact Pacific herring eggs and larvae at the terminal site. Alternatives 4B and 4D would bridge Sawmill Creek, which supports anadromous fish populations. The bridge would not encroach on the streambed. None of these impacts would be large enough to measurably affect fish and invertebrate populations in Lynn Canal.

The incremental effect of the Sawmill Cove Ferry Terminal on Pacific herring stock is relatively small; therefore, this would be an EFH impact because of the depressed herring stock in Lynn Canal. As explained in Sec. 5.3.3, Summary of Alt. 2A Impacts, several factors are part of the consideration for the depressed stock. For other EFH species, the direct loss of 3.2 acres of habitat from ferry terminal construction would not adversely affect any fish and invertebrate populations in Lynn Canal.

Alternatives 4B and 4D would result in improved access to Berners Bay north from Echo Cove to Sawmill Cove. This is likely to result in increased recreational fishing for anadromous fish along the Berners Bay shoreline to Sawmill Cove, as well as in Sawmill Creek. No boat ramps would be constructed along the highway for any of these alternatives. Therefore, they would not increase the number of access points in the project study area for boats other than small, highly portable recreational craft such as kayaks and canoes.

As discussed in Section 4.4.5 of the SDEIS, economic benefits associated with Alternative 4B would result in population growth in Juneau, Haines, and Skagway while the economic benefits of Alternative 4D would result in population growth in Juneau and Haines. This would increase the volume of effluent discharged from the wastewater treatment facilities in these communities. This increase would not reduce water quality in the receiving waters because these facilities must meet NPDES discharge limitations protective of aquatic life.

5.9 Cumulative Effects Analysis

5.9.1 Past, Present, and Reasonably Foreseeable Future Effects

There is the potential for all of the past, present, and reasonably foreseeable projects described in Section 4.9 of the SDEIS to impact water quality and potentially degrade EFH. Several of the foreseeable future projects would directly cause loss of EFH due to the placement of fill in the intertidal zone:

- Alaska Glacier Seafoods plant – 0.63 acres of fill for a pad, extending into Auke Nu Cove, and an 80-foot by 110-foot pile supported dock (U.S. Army Corps of Engineers [USACE], 2003).
- Goldbelt Cascade Point Marine Terminal Facility – 1.2 acres of fill for a break water and 1.6 acres dredged for a turning basin (USACE, 2004).
- Kensington Mine Slate Cove facilities – 3.6 acres of fill for a marine terminal (USACE, 2004).
- Otter Creek Hydroelectric Plant – 0.7 acres of fill in intertidal and subtidal habitat for a deep marine jetty and floating dock (USDA Forest Service, 2002).

Various hypotheses have been put forward as to why Lynn Canal herring stocks have declined, although none have been substantiated through careful scientific analysis. These hypotheses include one or some combination of the following factors: overfishing, increased predator populations, disease, habitat alteration or degradation (especially in Auke Bay), water pollution, and unfavorable oceanographic conditions (see Attachment C). Thus, one or more of these factors in Lynn Canal and/or Berners Bay could have affected Pacific herring stocks such that the species' ability to recover has been compromised and the population remains below harvestable levels. Past direct and indirect impacts on Pacific salmon, eulachon, crabs, and sculpin have not been observable at the population level.

Many of the effects from the reasonably foreseeable projects would be short-term and temporary, such as increased turbidity during construction. Other longer-term impacts on water quality could be realized due to effluent from the seafood plant, hydroelectric facility, and mine, and spills from vessels associated with the Cascade Point/Slate Cove improvements. Marine vessel and harbor operations could cause short-term impacts to water quality due to discharges (permitted and unintentional sanitary waste discharge), and unintentional fuel discharge. These water quality changes could result in mortality of individual Pacific herring, crabs, and sculpins. Other future foreseeable or ongoing events occurring within Lynn Canal that have the potential to impact habitat and fish and invertebrates include commercial, sport and subsistence/personal use fishing, and recreation.

5.9.2 Alternative 1 – No Action Alternative

The intertidal and shallow subtidal habitat that would be lost as a result of foreseeable future projects is used by juvenile salmon, particularly pink salmon, during their early marine life stages, as well as by prey species for fish stocks in Lynn Canal. When they first enter marine waters, pink salmon spend most of their time in a few centimeters of water (Groot and Margolis, 1991). Other juvenile salmonids such as chum, coho, and sockeye salmon also use shallow nearshore habitat for rearing but not to the same extent as pink salmon. Foreseeable future projects would result in the loss of approximately nine acres of nearshore habitat used by juvenile salmon. Because much of the Lynn Canal coastline provides suitable rearing habitat for juvenile salmon, this loss would not measurably effect salmon populations in Lynn Canal.

Construction of the dock facility at Slate Creek for the Kensington Gold Project could affect both adult eulachon returning to spawn and juvenile eulachon, depending on timing. Noise and increased boat traffic due to construction could disrupt the migration of some adult eulachon returning to spawn if these activities occur in the April to May spawning period. Avoiding construction during this period could mitigate this effect. Some juvenile eulachon feeding in Berners Bay could be affected by dock construction at Slate Creek; however, these fish are found mostly along the bottom in deeper water (Smith and Saalfeld, 1955). Because construction would impact a small area of eulachon foraging habitat and construction would last for a short period of time, it would not measurably effect the populations of eulachon in Lynn Canal (USFS, 2004).

Goldbelt Cascade Point Marine Terminal Facility includes 1.2 acres of fill for a break water and 1.6 acres dredged for a turning basin (USACE, 2004). Therefore, approximately three acres of potential spawning habitat for Pacific herring at Cascade Point would be lost due to that project. If the filled and dredged area at Cascade Point was entirely lost for spawning, approximately 350 feet of shoreline would be affected (USFS, 2004). This is equivalent to about two percent of the along-shore herring spawning length (approximately three miles) observed in Berners Bay in 2003.

The Kensington Gold Project and Alaska Glacier Seafoods project would increase marine vessel traffic in Lynn Canal. Until recently, treatment of wastewater discharged from marine vessels did not need to meet water quality standards that were completely protective of aquatic life. New compliance regulations effective beginning in 2004 require wastewater discharges to meet AWQSs. Therefore, even though marine vessel traffic and corresponding wastewater discharges may increase under the No Action Alternative those discharges should not alter water quality in Lynn Canal because of improved wastewater treatment.

5.9.3 Alternatives 2, 2A, 2B, and 2C

Alternatives 2 through 2C would be on the shoreline at several locations between Sherman Point and the Katzehin River. This would result in filling 21.9 acres of intertidal and shallow subtidal habitat. Alternatives 2 and 2B would fill 4.3 acres of intertidal and subtidal habitat for the proposed Katzehin Ferry Terminal, as well as dredge an additional 4.5 acres of subtidal habitat for a ferry mooring basin at the terminal site. Alternative 2A would include this fill and dredge area at Katzehin, as well as filling and dredging 4.3 acres of intertidal and subtidal habitat at Sawmill Cove (3.2 acres) and Slate Cove (1.1 acres) in Berners Bay. Therefore, Alternatives 2 and 2B would impact about 30.8 acres of intertidal and subtidal habitat, Alternative 2A would impact about 35.1 acres of these habitats, and Alternative 2C would impact 21.9 acres of these habitats.

Alternatives 2 through 2C in combination with foreseeable future projects would result in the loss of 30.8 (Alternatives 2 and 2B) to 35.1 (Alternative 2A) acres of nearshore intertidal and shallow subtidal habitat used by juvenile salmon. Because much of the Lynn Canal coastline provides suitable rearing habitat for juvenile salmon, this loss would not measurably effect salmon populations in Lynn Canal.

The Slate Creek dock facilities for the Kensington Gold Project in combination with the Slate Cove Ferry Terminal for Alternative 2A may impact several acres of foraging habitat for juvenile eulachon. These fish are found mostly along the bottom in deeper water (Smith and Saalfeld, 1955) than these two facilities; therefore, this cumulative habitat loss would not be large enough to measurably effect eulachon populations in Lynn Canal. Eulachon also use the Katzehin River for spawning. The Katzehin Ferry Terminal proposed for Alternatives 2, 2A, and 2B is used for spawning by euchalon. Because the terminal would be located north of the river delta, it would not impact spawning runs of this species.

The Goldbelt Cascade Point marine facility and the Sawmill Cove Ferry Terminal proposed for Alternative 2A would have a cumulative impact on existing Pacific herring spawning habitat. The Goldbelt Cascade Point marine facility breakwater and dredging would impact approximately 2.8 acres of intertidal and subtidal habitat; and the Sawmill Cove Ferry Terminal would require fill and dredge of 3.2 acres of intertidal and subtidal habitat in areas that Pacific herring are known to currently spawn in Berners Bay. Based on 2003 site surveys, the proposed Sawmill Cove terminal site contains herring spawning habitat. Alternative 2A in combination with foreseeable future projects would impact a total of approximately six acres of spawning habitat currently used by Pacific herring in Berners Bay. The footprint of the Sawmill Cove Ferry Terminal is approximately 300 feet of shoreline at MLLW, which is equivalent to less than two percent of the along-shore herring spawning length observed in Berners Bay in 2003. The footprint of the Cascade Point marine facility in combination with the Sawmill Cove terminal proposed for Alternative 2A would result in the cumulative loss of 4.4 percent of the known along-shore Pacific herring spawning habitat in Berners Bay. This would be a cumulative impact to Pacific herring.

Alternatives 2 through 2C in combination with other foreseeable future projects in the region were evaluated for the potential to impact essential fish habitat through changes in water quality. This evaluation considered discharges of sanitary wastewater from marine and ferry terminals as well as marine vessels, leakage of fuels and lubricants from marine vessels, highway stormwater runoff, and catastrophic spills from marine vessels and vehicles using a highway.

Alternatives 2, 2A, and 2B would have a new ferry terminal at Katzehin, and Alternative 2A would also have new ferry terminals at Sawmill Cove and Slate Cove. Sanitary wastewater would be discharged from the Katzehin terminal into Lynn Canal and wastewater from the Sawmill Cove and Slate Cove terminals would be discharged into Berners Bay. These discharges would not substantially alter water quality. Wastewater would go through tertiary treatment using ultraviolet light disinfection prior to discharge and discharges would be at the appropriate distance from shore and depth of water to meet permit guidelines for mixing. Treated wastewater would meet AWQSs protective of aquatic life. There are no plans for wastewater treatment and discharge at the proposed Coeur Slate Cove and Goldbelt Cascade Point marine facilities in Berners Bay. Because discharge of wastewater from ferry terminals proposed for Alternatives 2 through 2B would not result in substantial water quality changes in Berners Bay and other foreseeable future marine facilities that would be located there do not include wastewater treatment and discharge facilities, there would be no cumulative water quality impacts from this source.

Alternatives 2 through 2C would end AMHS service at Auke Bay but would increase shuttle ferry traffic in Lynn Canal. Shuttle ferries would be equipped with sanitary waste holding tanks that would be pumped out and the waste would be treated onshore at an appropriate treatment plant or wastewater would be treated onboard to appropriate standards prior to discharge. Therefore, wastewater from these ferries would not impact water quality in Lynn Canal and Berners Bay, and would not contribute to cumulative water quality impacts.

The increased marine vessel traffic in Berners Bay associated with Alternative 2A and foreseeable future projects at Slate Creek and Cascade Point could lead to an increase in total petroleum hydrocarbons (TPHs) in the bay from fuel and lubricant leaks. TPHs consist of a mixture of light and heavy hydrocarbons and include polycyclic aromatic hydrocarbons (PAHs). Lighter hydrocarbons, like those contained in diesel fuel, are generally more volatile and water-soluble and therefore associated with potential acute hazards to aquatic life. The larger and heavier hydrocarbons are more persistent in the environment and have the potential for chronic toxicological effects (USFS, 2004).

In studies on Pacific herring, the National Oceanic and Atmospheric Administration (NOAA) found a direct relationship between PAH accumulation in muscle tissue and ovaries of exposed fish and PAH concentrations of oil in water. The study noted that PAH exposure resulted in a depression of immune function and expression of viral symptoms (USFS, 2004).

Herring eggs exposed to TPHs experienced shorter incubation times, and reduced egg survival, larval survival, and swimming ability as well as morphological abnormalities. At concentrations of 7.6 micrograms/liter (µg/L), significant larval abnormalities were observed in Pacific herring, and adverse effects from exposure to PAHs have been observed at concentrations of about 0.7 µg/L (USFS, 2004).

The highest concentrations of PAHs in the water of San Francisco Bay were reported at 0.5 µg/L. The marine vessel traffic in that bay is orders of magnitude larger than would occur in Berners Bay with Alternative 2A and foreseeable future projects, and San Francisco Bay receives large volumes of urban runoff containing TPHs. It should also be noted that San Francisco Bay has supported a viable Pacific herring fishery for many decades.

Although hydrocarbon levels near AMHS ferry terminals have not been monitored NOAA believes normal levels in these areas would be very low (USFS, 2004). Hydrocarbon levels approaching those observed in San Francisco Bay may cause adverse effects on Pacific herring; however, it is likely that fuel leakage from the cumulative marine traffic that could occur in Berners Bay would produce hydrocarbon levels several orders of magnitude lower than those found in San Francisco Bay. Therefore, fuel leakage from the cumulative increase in ferry traffic associated with Alternative 2A and foreseeable future projects is not likely to impact essential fish habitat in Berners Bay.

The highway proposed for Alternatives 2, 2B, and 2C would be located along the eastern shore of Berners Bay, and at times it would be within 200 feet of the shore. Results of stormwater research by the FHWA indicate that stormwater runoff from low to medium traffic volumes (under 30,000 vehicles per day) on rural highways exerts minimal to no impact on the aquatic components of most receiving waters (USDOT & FHWA, 1987). Annual average daily traffic (annual ADT) on the proposed highway is projected to range from 670 (Alternatives 2A and 2B) to 930 (Alternative 2) vehicles in 2038, which is about 3 percent of the maximum traffic volume considered in the FHWA research. The maximum peak week ADT for any of the alternatives is projected to reach 3,250 (Alternative 2) vehicles in 2038, or about 10 percent of the maximum traffic volume considered in the FHWA research.

Studies conducted in Anchorage, Alaska, under the Municipality of Anchorage Watershed Management Program similarly concluded that street runoff has minimal impacts to the water quality of receiving waters from most potential pollutants (MOA, 2000). These studies evaluated runoff from residential streets (<2,000 ADT) to major arterials (>20,000 ADT), including water quality impacts from snowmelt. The studies showed dissolved concentrations of calcium, chromium, magnesium, and zinc to be below AWQSs and PAHs to be below EPA water quality criteria. Only dissolved concentrations of copper and lead were noted to be above their

AWQSs; however, modest dilution would likely reduce these concentrations below their AWQSs. Because of the rural setting of Alternatives 2, 2B, and 2C and the predicted low annual ADT, lower concentrations of pollutants would be present in runoff from the highway proposed for these alternatives than were found in the Anchorage studies. Based on the results of those studies and FHWA research, runoff from Alternatives 2, 2B, and 2C would not cause water quality impacts in Berners Bay.

The potential for a catastrophic release of petroleum in Berners Bay would increase with Alternative 2A and the foreseeable future projects. Depending on the timing and location of such a spill, it could substantially impact the spawning population of eulachon that uses the Antler, Lace, and Berners rivers and the Pacific herring spawning population in the bay.

5.9.4 Alternative 3

Alternative 3 would be on the shoreline approximately two miles north of the Endicott River, resulting in the fill of 0.09 acre of intertidal habitat. Construction of the causeway between the proposed bridges over the Chilkat River/Inlet would also fill 4.8 acres of intertidal habitat. The proposed ferry terminals at Sawmill Cove and William Henry Bay would fill and dredge a total of about eight acres of intertidal and shallow subtidal habitat.

As discussed in Section 5.9.2, nearshore intertidal and shallow subtidal habitat is used by juvenile salmon, particularly pink salmon, during their early marine life stages, as well as by prey species for fish stocks in Lynn Canal. Alternative 3 in combination with foreseeable future projects would result in the loss of 21.9 acres of this habitat. Because much of the Lynn Canal coastline provides suitable rearing habitat for juvenile salmon, this loss would not measurably effect salmon populations in Lynn Canal.

The Goldbelt Cascade Point marine facility and the Sawmill Cove Ferry Terminal proposed for Alternative 3 would have a cumulative impact on existing Pacific herring spawning habitat. The Goldbelt Cascade Point marine facility breakwater and dredging would impact approximately 2.8 acres of intertidal and subtidal habitat; and the Sawmill Cove Ferry Terminal would require fill and dredge of 3.2 acres of intertidal and subtidal habitat in areas that Pacific herring are known to currently spawn in Berners Bay. Based on a 2003 site survey, the proposed Sawmill Cove terminal site is suitable herring spawning habitat because it supports patches of blade kelp that were sparse but persistent and evenly distributed throughout the subtidal area. There is no eelgrass or stalked kelp. Alternative 3 in combination with foreseeable future projects would impact a total of approximately six acres of spawning habitat currently used by Pacific herring in Berners Bay. The footprint of the Sawmill Cove Ferry Terminal is approximately 300 feet of shoreline at mean lower low water, which is equivalent to less than two percent of the along-shore herring spawning length observed in Berners Bay in 2003. The footprint of the Cascade Point marine facility in combination with the Sawmill Cove terminal proposed for Alternative 3 would result in the cumulative loss of 4.4 percent of the known along-shore Pacific herring spawning habitat in Berners Bay. This would be a cumulative impact to Pacific herring.

Approximately 4.8 acres of this habitat would be lost to terminal filling and dredging at William Henry Bay. However, Pacific herring spawning is currently limited to Berners Bay and no spawning takes place in any of these other locations in Lynn Canal.

Alternative 3 in combination with other foreseeable future projects in the region were evaluated for the potential to impact essential fish habitat through changes in water quality. This evaluation considered discharges of sanitary wastewater from marine and ferry terminals as well as marine vessels, leakage of fuels and lubricants from marine vessels, highway stormwater runoff, and catastrophic spills from marine vessels and vehicles using a highway.

Sanitary wastewater would be discharged from the Sawmill Cove terminal into Berners Bay and from the William Henry Bay terminal into that bay. These discharges would not substantially alter water quality. Wastewater would go through tertiary treatment using ultraviolet light disinfection prior to discharge and discharges would be at the appropriate distance from shore and depth of water to meet permit guidelines for mixing. Treated wastewater would meet AWQSs protective of aquatic life. There are no plans for wastewater treatment and discharge at the proposed Slate Creek and Cascade Point marine facilities in Berners Bay. Because discharge of wastewater from ferry terminals proposed for Alternative 3 would not result in substantial water quality changes in Berners Bay and other foreseeable future marine facilities that would be located there do not include wastewater treatment and discharge facilities, there would be no cumulative water quality impacts from this source.

Alternative 3 would end AMHS service at Auke Bay but would increase shuttle ferry traffic in Lynn Canal and introduce shuttle ferry traffic in Berners Bay. Shuttle ferries would be equipped with sanitary waste holding tanks that would be pumped out and the waste would be treated onshore at an appropriate treatment plant or wastewater would be treated onboard to appropriate standards prior to discharge. Therefore, wastewater from these ferries would not impact water quality in Lynn Canal and Berners Bay, and would not contribute to cumulative water quality impacts.

The increased marine vessel traffic in Berners Bay associated with Alternative 3 and foreseeable future projects at Slate Creek and Cascade Point could lead to an increase in total petroleum hydrocarbons (TPHs) in the bay from fuel and lubricant leaks. However, because of the small volume of vessel traffic that would result from Alternative 3 and foreseeable future projects, it is unlikely that hydrocarbon leaks would be large enough to impact essential fish habitat in Berners Bay.

The highway proposed for Alternative 3 would be located along the eastern shore of Berners Bay to Sawmill Cove. Based on the results of stormwater runoff studies conducted by the Municipality of Anchorage and FHWA, runoff from Alternative 3 would not cause water quality impacts in Berners Bay.

The potential for a catastrophic release of petroleum in Berners Bay would increase with Alternative 3 and the foreseeable future projects. Depending on the timing and location of such a spill, it could substantially impact the Pacific herring spawning population in the bay.

5.9.5 Alternatives 4A and 4C

Alternatives 4A and 4C in combination with the foreseeable future expansion of the Alaska Glacier Seafoods Plant would result in the loss of about 1.5 acres of nearshore intertidal and shallow subtidal habitat in Auke Bay. Other marine facilities have been constructed in Auke Bay including the existing Auke Bay ferry terminal, a boat launch ramp, several marinas including fueling facilities, a harbormaster’s office, associated parking, and residential and commercial wastewater facilities. Although the acreage of impacted intertidal and subtidal habitat has not been computed, development occurs all along the waterfront of Auke Bay. A large portion of most of the facilities is on the surface of the water away from the nearshore habitat (such as the finger float system of a marina), and parts of the facilities occupy a smaller portion of intertidal or subtidal habitat (such as a staging dock and access ramp). In such instances, the amount of nearshore habitat impacted is not commensurate with the size of the entire development. Because the remaining Auke Bay nearshore intertidal and subtidal habitat and most of the Lynn Canal coastline provides suitable rearing habitat for juvenile salmon, prey species, and crabs, this loss would not measurably effect fish and invertebrate populations in Lynn Canal.

5.9.6 Alternatives 4B and 4D

Alternatives 4B and 4D in combination with the foreseeable future expansion of the Alaska Glacier Seafoods Plant would result in the loss of about 1.5 acres of nearshore intertidal and shallow subtidal habitat in Auke Bay. Other marine facilities have been constructed in Auke Bay including the existing Auke Bay ferry terminal, a boat launch ramp, several marinas including fueling facilities, a harbormaster's office, associated parking, and residential and commercial wastewater facilities. Although the acreage of impacted intertidal and subtidal habitat has not been computed, development occurs all along the waterfront of Auke Bay. A large portion of most of the facilities is on the surface of the water away from the nearshore habitat (such as the finger float system of a marina), and parts of the facilities occupy a smaller portion of intertidal or subtidal habitat (such as a staging dock and access ramp). In such instances, the amount of nearshore habitat impacted is not commensurate with the size of the entire development. Because the remaining Auke Bay nearshore intertidal and subtidal habitat and most of the Lynn Canal coastline provides suitable rearing habitat for juvenile salmon, prey species, and crabs, this loss would not measurably effect fish and invertebrate populations in Lynn Canal.

Alternatives 4B and 4D would result in the loss of 3.2 acres of intertidal and subtidal habitat from dredging and filling at the proposed Sawmill Cove Ferry Terminal site. As discussed in Section 4.9.1.2, nearshore intertidal and shallow subtidal habitat is used by juvenile salmon, particularly pink salmon, during their early marine life stages, as well as by prey species for fish stocks in Lynn Canal. Alternatives 4B and 4D in combination with foreseeable future projects would result in the loss of about 10 acres of this habitat. Because much of the Lynn Canal coastline provides suitable rearing habitat for juvenile salmon, this loss would not measurably effect salmon populations in Lynn Canal.

The Goldbelt Cascade Point marine facility and the Sawmill Cove Ferry Terminal proposed for Alternatives 4B and 4D would have a cumulative impact on existing Pacific herring spawning habitat. The Goldbelt Cascade Point marine facility breakwater and dredging would impact approximately 2.8 acres of intertidal and subtidal habitat; and the Sawmill Cove Ferry Terminal would require fill and dredge of 3.2 acres of intertidal and subtidal habitat in areas that Pacific herring are known to currently spawn in Berners Bay. Based on 2003 site surveys, the proposed Sawmill Cove terminal site is suitable habitat for Pacific herring spawning. Alternatives 4B and 4D in combination with foreseeable future projects would impact a total of approximately six acres of spawning habitat currently used by Pacific herring in Berners Bay. The footprint of the Sawmill Cove Ferry Terminal is approximately 300 feet of shoreline at mean lower low water, which is equivalent to less than two percent of the along-shore herring spawning length observed in Berners Bay in 2003. The footprint of the Cascade Point marine facility in combination with the Sawmill Cove terminal proposed for Alternatives 4B and 4D would result in the cumulative loss of 4.4 percent of the known along-shore Pacific herring spawning habitat in Berners Bay. This would be a cumulative impact to Pacific herring because the regional population is depressed.

Alternatives 4B and 4D in combination with other foreseeable future projects in the region were evaluated for the potential to impact essential fish habitat through changes in water quality. This evaluation considered discharges of sanitary wastewater from marine and ferry terminals as well as marine vessels, leakage of fuels and lubricants from marine vessels, highway stormwater runoff, and catastrophic spills from marine vessels and vehicles using a highway.

Sanitary wastewater would be discharged from the Sawmill Cove terminal into Berners Bay. This discharge would not substantially alter water quality. Wastewater would go through tertiary treatment using ultraviolet light disinfection prior to discharge and discharges would be at the appropriate distance from shore and depth of water to meet permit guidelines for mixing.

Treated wastewater would meet AWQSs protective of aquatic life. There are no plans for wastewater treatment and discharge at the proposed Slate Creek and Cascade Point marine facilities in Berners Bay. Because discharge of wastewater from the ferry terminal proposed for Alternatives 4B and 4D would not result in substantial water quality changes in Berners Bay and other foreseeable future marine facilities that would be located there do not include wastewater treatment and discharge facilities, there would be no cumulative water quality impacts from this source.

Sanitary waste discharged from AMHS vessels in Lynn Canal must meet AWQSs. Shuttle ferries would be equipped with sanitary waste holding tanks that would be pumped out and the waste would be treated onshore at an appropriate treatment plant or wastewater would be treated onboard to appropriate standards prior to discharge. Therefore, wastewater from these ferries would not impact water quality in Lynn Canal and Berners Bay, and would not contribute to cumulative water quality impacts.

The increased marine vessel traffic in Berners Bay associated with Alternatives 4B and 4D and foreseeable future projects at Slate Creek and Cascade Point could lead to an increase in total petroleum hydrocarbons (TPHs) in the bay from fuel and lubricant leaks. However, because of the small volume of vessel traffic that would result from Alternatives 4B and 4D and foreseeable future projects, it is unlikely that hydrocarbon leaks would be large enough to impact essential fish habitat in Berners Bay.

The highway proposed for Alternatives 4B and 4D would be located along the eastern shore of Berners Bay to Sawmill Cove. Based on the results of stormwater runoff studies conducted by the Municipality of Anchorage and FHWA, runoff from Alternatives 4B and 4D would not cause water quality impacts in Berners Bay.

The potential for a catastrophic release of petroleum in Berners Bay would increase with Alternatives 4B and 4D and the foreseeable future projects. Depending on the timing and location of such a spill, it could substantially impact the Pacific herring spawning population in the bay.

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6.0 DOT&PF PROPOSED CONSERVATION MEASURES

The following conservation measures would be incorporated into the project to avoid, minimize, and mitigate impacts to EFH. These are general measures that would be modified to specifically address details of the selected alternative.

Highway

<u>Construction:</u>

- DOT&PF would develop an Erosion and Sedimentation Control Plan (ESCP); NMFS and other resource agencies would be provided an opportunity to review the plan.
- The contractor would prepare and implement a Storm Water Pollution Prevention Plan (SWPPP).
- DOT&PF would incorporate BMPs developed in accordance with the Environmental Protection Agency Storm Water Management for Construction Activities: Developing Pollution and Prevention plans and Best Management Practices" to minimize the introduction of sediment and siltation into streams and marine waters.
- Fill near intertidal areas would be placed during low tides to avoid in-water fill to minimize introduction of sediments into the marine environment.
- Fill would be placed in a seaward direction from shore, avoiding in-water use of construction equipment.
- Fill material would be free from petroleum or other toxic substances.
- Fill would be placed on excavated ground within the shortest reasonable time, so that disturbed soils are not left exposed for extended periods.
- Silt and sediment from site excavation and fill materials would not enter wetlands or waters outside the work area. If silt and sediment are evident in water outside the excavation and fill area, appropriate control and containment measures will be applied.
- The fill embankments would be vegetated for stabilization, where appropriate, or stabilized with riprap to minimize erosion and sedimentation. Riprap would be free from fines and organics to the extent practicable, and free from petroleum or other toxic contaminants.
- No excavated soil or vegetation removed from the project area would be disposed of in waters, near streams, or wetlands.
- Work would be timed to avoid sedimentation entering streams and marine waters through runoff.
- No sidecasting would occur in intertidal and subtidal areas that would be likely to serve as refuge or areas important for the spawning breeding, or other life cycle of EFH species.
- The perimeter of the site preparation, excavation, and fill areas would be staked prior to construction to prevent inadvertent encroachment outside the necessary area.
- Silt fences would be used adjacent to EFH anadromous stream channels, near the toe of the fill.
- Precautions and controls would be used to prevent incidental and accidental discharge of petroleum products from construction equipment.

- Work would be done in a manner to prevent the spread of invasive plant species.
- In clearing the corridor, timber would not be yarded over or through wetlands or stream floodplains.

Operation:

- Runoff would be controlled through drainage ditches.
- Snow removed from the highway would be dispersed along the highway. No large amounts would be deposited in one place.

Streams

Construction:

- Equipment would not enter the streams or rivers for single-span or multi-span bridges. Typical construction techniques would include the erection of falsework to provide a platform for equipment.
- Timing windows would be implemented to minimize impacts from short-term increases in turbidity during construction of the multi-span bridges, and for all crossings to avoid disturbance of fish during sensitive times, such as spawning..
- Single-span and multi-span bridges would not encroach upon the stream banks, thus avoiding alteration of stream banks.

Operation:

- All anadromous streams would be crossed by bridges to provide fish passage and to minimize impacts on stream function.

Ferry terminals

Construction:

- Fill would be placed from shore outward, avoiding in-water use of construction equipment.
- Fill would be placed during lower tides to the extent practicable to minimize in-water fill and sedimentation.
- Fill material would be free from petroleum or other toxic substances.
- Fill material would be stabilized with riprap to minimize sedimentation. Riprap would be free from fines and suspendible material to the extent practicable, and free from petroleum or other toxic contaminants.
- A silt boom would be used around the dredge area during dredging.
- Dredging and driving of dolphins would be accomplished by equipment staged on a floating barge.
- Timing restrictions would be incorporated to minimize disturbance and effects of sedimentation from placing fill, laying the outfall, dredging and pile-driving to fish.
- Timing restrictions would be incorporated to minimize effects of noise and vibrations associated with pile driving and dredging.

- Piles would be driven during low tide periods in intertidal and shallow subtidal areas to prevent injuries to fish.
- A vibratory hammer would be used if hollow steel piles are used. If conditions require the use of impact hammers, the pile should be driven as deep as possible with a vibratory hammer prior to use of the impact hammer.
- If peak sound pressure levels from deepwater pile driving exceed the threshold for injury to fish, measures would be implemented to reduce sound pressure.
- All staging, fueling, and servicing operations would be conducted at least 100 feet away from all streams and wetlands.
- Staking would be placed around the perimeter of the footprint of the project to avoid additional impact outside the footprint from construction activities.

Operation:

- Parking lot runoff would be controlled to avoid introduction of petroleum contaminants into the waters, by monitoring and maintaining oil-water separators.
- Wastewater discharge would undergo tertiary treatment, disinfection with UV light.
- Effluent limitations in the NPDES permit would be implemented.
- Sewage sludge would be transported to sewer treatment plants in Juneau, or Skagway.

Ferry operations

- BMPs would be incorporated to prevent and clean up fuel spills.
- Ferries would carry oil-absorbent materials for oil spill cleanup.

Other conservation measures

- Temporary barge landing sites, which would be identified during design, would be located in sites already providing access, previously disturbed areas, and highway fill locations, where practicable. After construction, the landing sites would be re-contoured to original grade and revegetated as applicable.
- Staging, fueling, and servicing operations would be conducted at least 100 feet away from all streams and wetlands.

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7.0 AGENCY DETERMINATION OF EFFECTS

Based on the scope and nature of impacts expected from the project, minimization of impacts, and the proposed mitigation measures, the Alaska Department of Transportation and Public Facilities (DOT&PF), on behalf of the Federal Highway Administration (FHWA), has determined that no substantial adverse individual or cumulative effects on EFH in the project area would occur under any project alternative.

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8.0 LIST OF PREPARERS

Sue Ban	Senior Biologist URS Corporation M.S. Biological Oceanography, B.S. Biology Technical lead for *EFH Assessment* Author of technical report
Dave Erikson	Senior Biologist URS Corporation M.S. Biology, B.S. Wildlife Biology Senior review of document
Kim Busse	Biologist URS Corporation B.S. Biology Information collection/incorporation, technical review
Joyce Payne	Senior Biologist URS Corporation M.S. and B.S., Agricultural Biology Impacts analysis and senior review
Gregory Williams	Battelle, Pacific Northwest Division of Battelle Memorial Institute Author of *Reconnaissance Evaluation of Ecological Effects to Forage Fish Populations Associated with the Juneau Access Improvements Projects* (Appendix C to this EFH Assessment report)

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FIGURES

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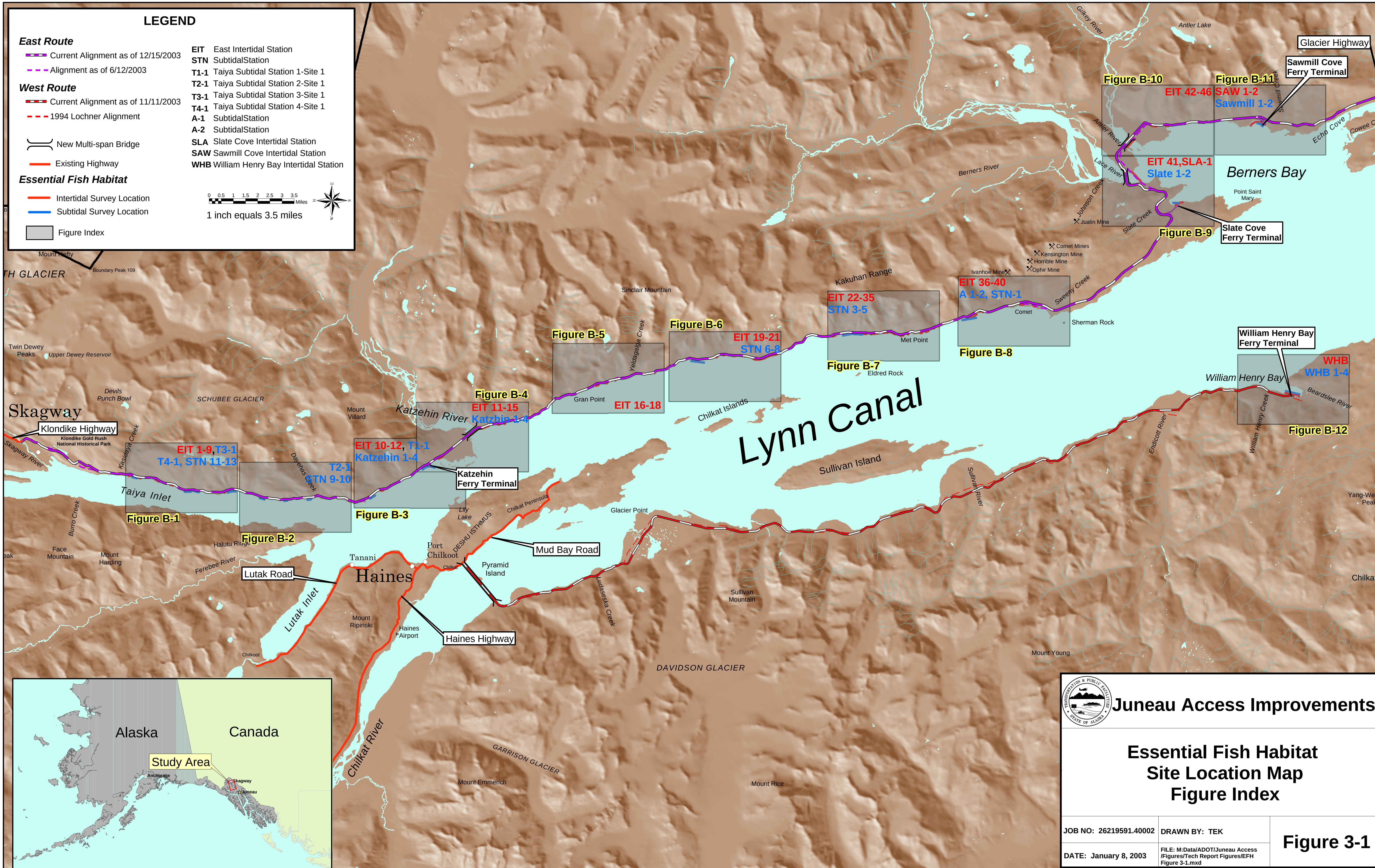

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East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
West Route
Current Alignment as of 11/11/2003
1994 Lochner Alignment
New Multi-span Bridge
Existing Highway
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
Figure Index
EIT East Intertidal Station
STN SubtidalStation
T1-1 Taiya Subtidal Station 1-Site 1
T2-1 Taiya Subtidal Station 2-Site 1
T3-1 Taiya Subtidal Station 3-Site 1
T4-1 Taiya Subtidal Station 4-Site 1
A-1 SubtidalStation
A-2 SubtidalStation
SLA Slate Cove Intertidal Station
SAW Sawmill Cove Intertidal Station
WHB William Henry Bay Intertidal Station
1 inch equals 3.5 miles
Lynn Canal
Berners Bay
Skagway
Haines
Klondike Highway
Glacier Highway
Sawmill Cove Ferry Terminal
Slate Cove Ferry Terminal
William Henry Bay Ferry Terminal
Katzehin Ferry Terminal
Mud Bay Road
Lutak Road
Haines Highway
Figure B-1
Figure B-2
Figure B-3
Figure B-4
Figure B-5
Figure B-6
Figure B-7
Figure B-8
Figure B-9
Figure B-10
Figure B-11
Figure B-12
EIT 1-9, T3-1
T4-1, STN 11-13
T2-1
STN 9-10
EIT 10-12, T1-1
Katzehin 1-4
EIT 11-15
Katzehin 1-4
EIT 16-18
EIT 19-21
STN 6-8
EIT 22-35
STN 3-5
EIT 36-40
A 1-2, STN-1
EIT 41,SLA-1
Slate 1-2
EIT 42-46
SAW 1-2
Sawmill 1-2
WHB
WHB 1-4
Taiya Inlet
Katzehin River
Chilkat Islands
Sullivan Island
Lutak Inlet
Chilkat River
William Henry Bay
DAVIDSON GLACIER
GARRISON GLACIER
Alaska
Canada
Study Area
Juneau Access Improvements
Essential Fish Habitat
Site Location Map
Figure Index
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DATE: January 8, 2003
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Figure 3-1

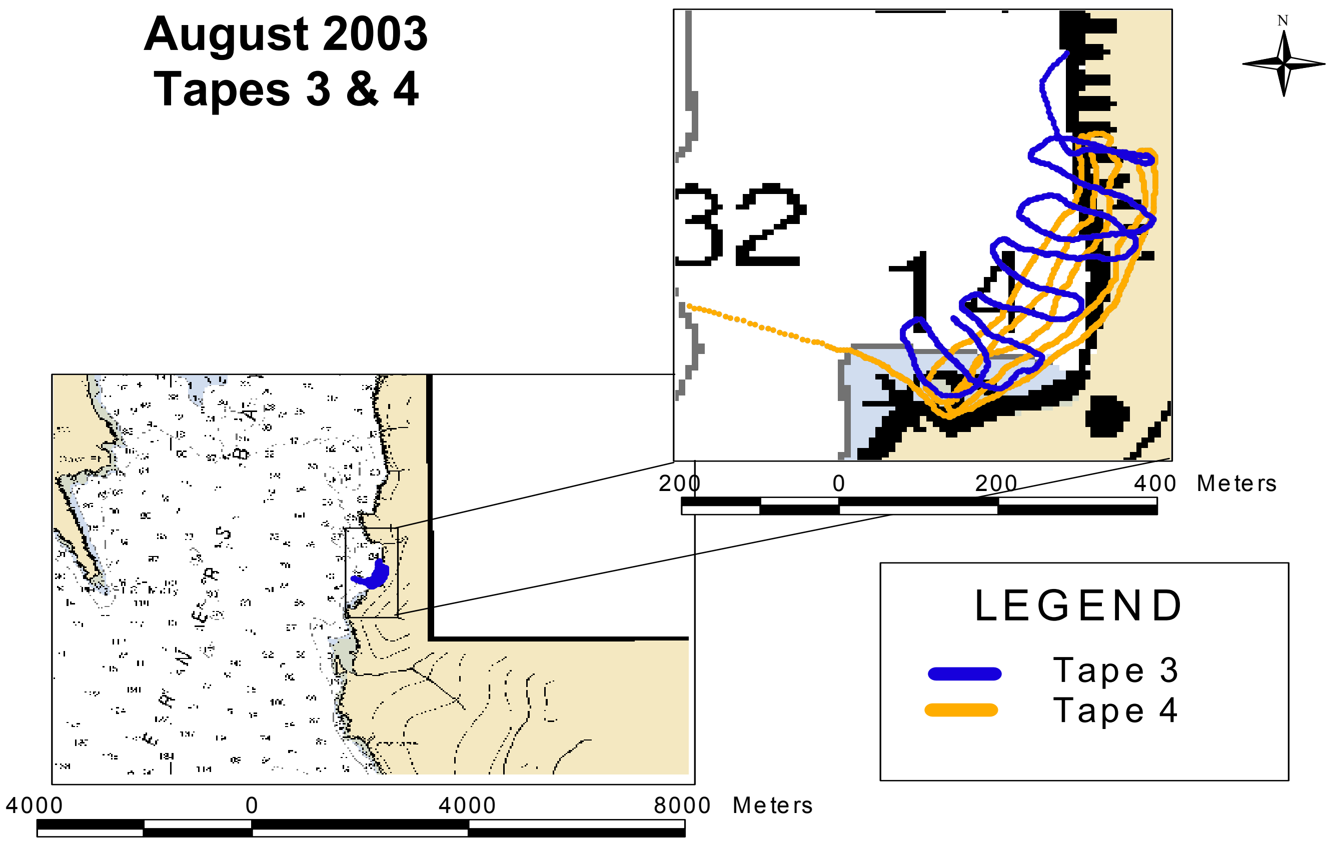

Figure 4-1 Subtidal Video Trackline Locations Sawmill Cove

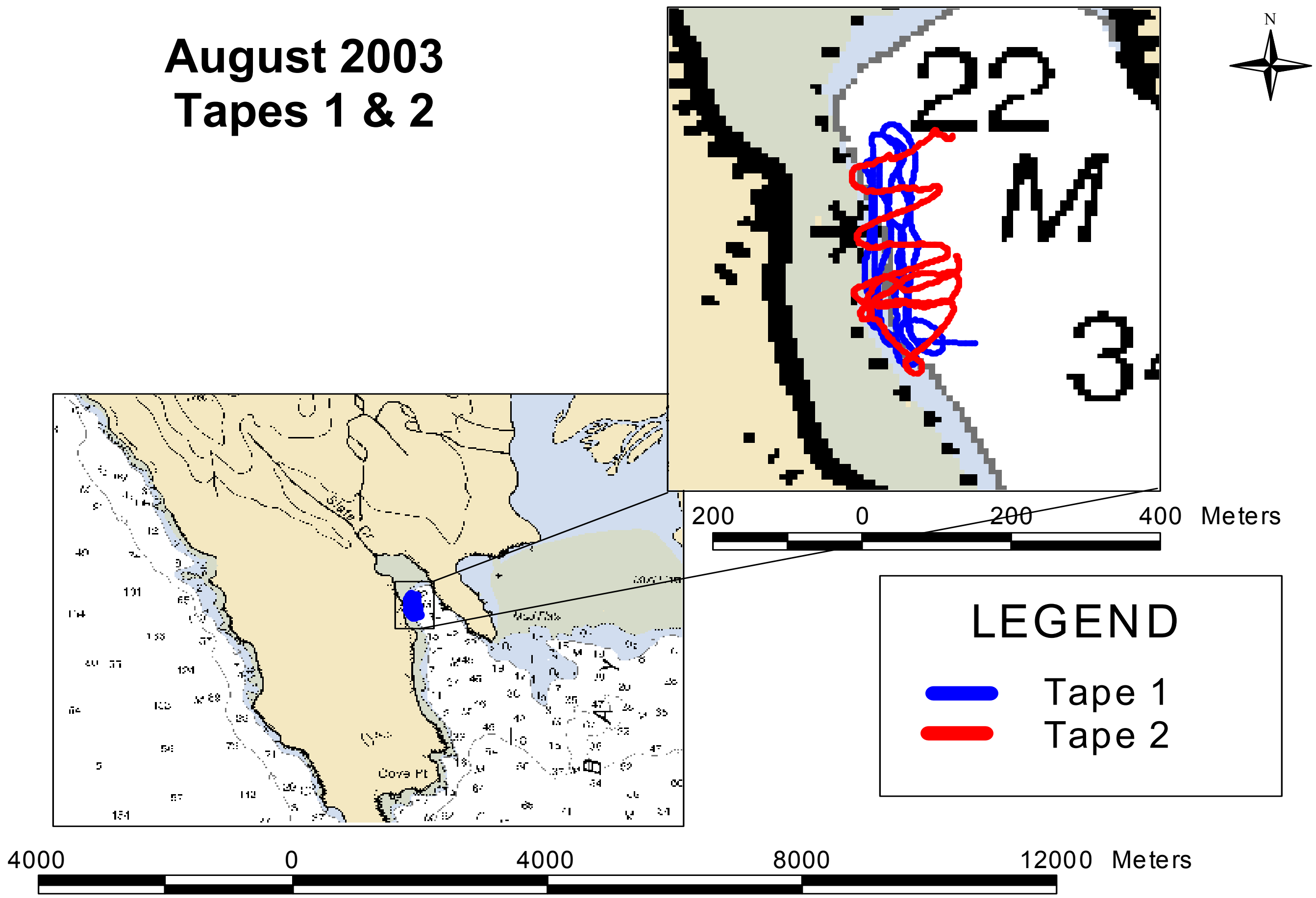

Figure 4-2 Subtidal Video Trackline Locations Slate Cove

August 2003
Tapes 12, 13, & 14

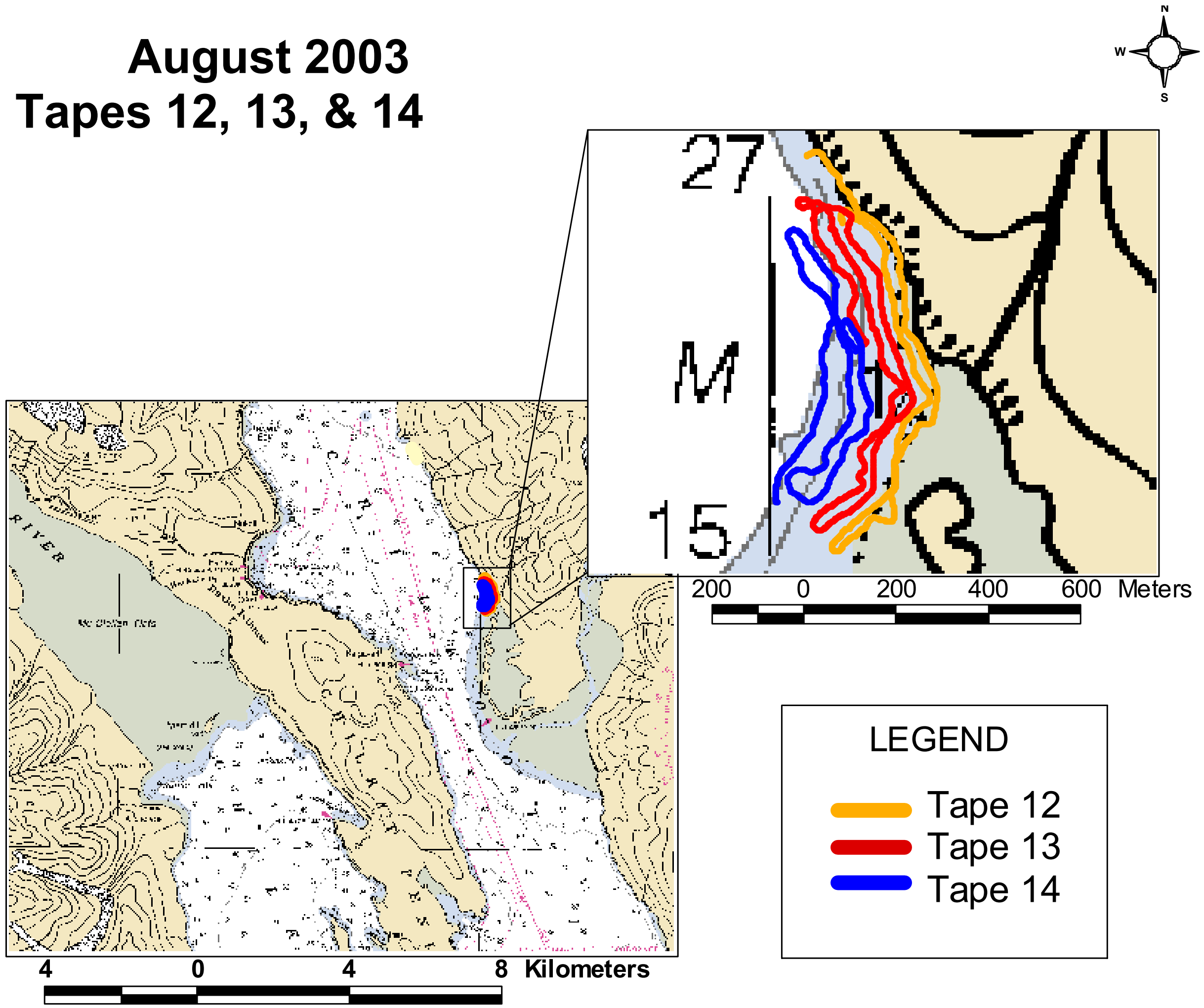

Figure 4-3 Subtidal Video Trackline Locations Katzehin Terminal Site

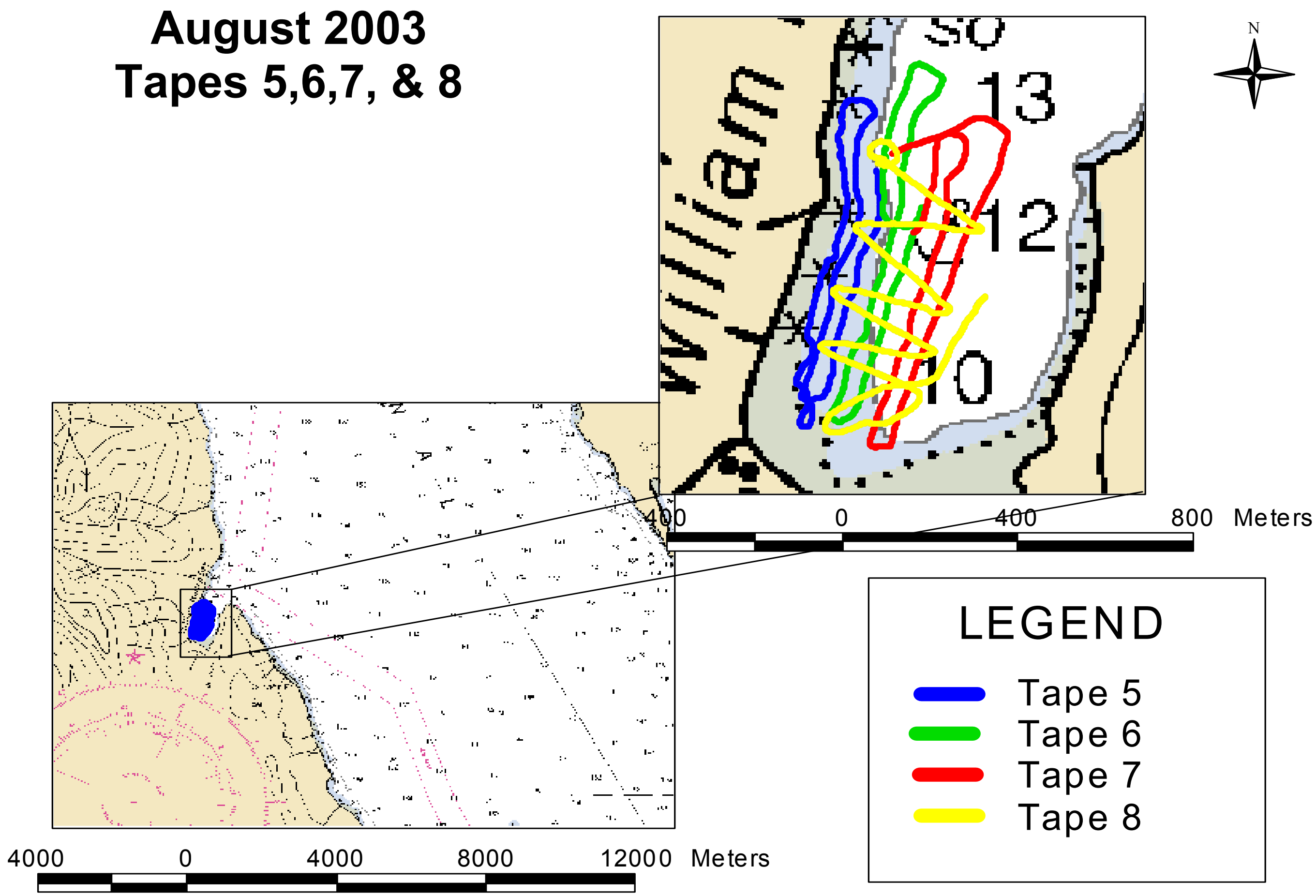

Figure 4-4 Subtidal Video Trackline Locations William Henry Bay

ATTACHMENT A
INTERTIDAL SURVEY FIELD PHOTOS

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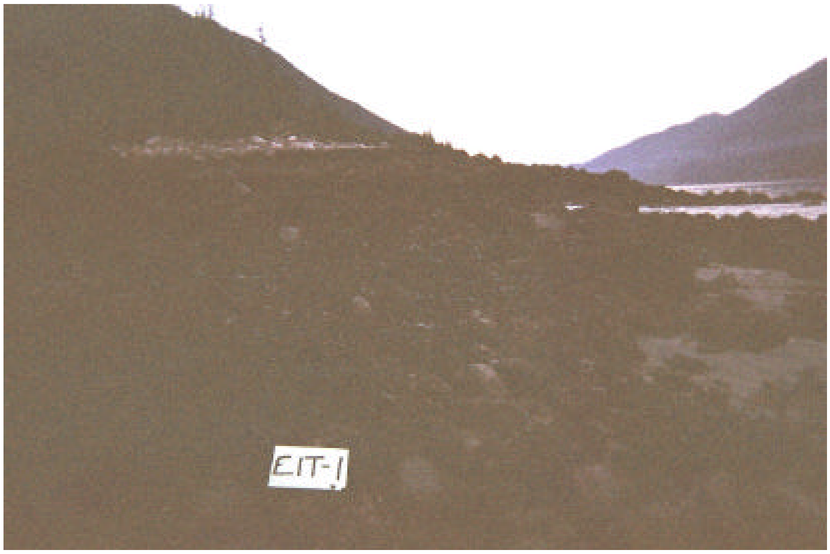

Photo ID: EIT-01. *Mytilus* beds at Kasidaya Creek (Taiya Inlet area). *Note: Alignment moved; this site no longer directly affected* (see Figure B-1).

Photo ID: EIT-01A. Mouth of Kasidaya Creek (Taiya Inlet area). *Note: Alignment moved; this site no longer directly affected* (see Figure B-1).

Photo ID: EIT-02. Typical zonation, including bands of *Fucus* and *Mytilus* on boulder beach, just south of Kasidaya Creek (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-02A. Typical zonation, including bands of *Fucus* and *Mytilus* on boulder beach, just south of Kasidaya Creek (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-03. Typical zonation, including bands of *Fucus* and *Mytilus* on boulder beach, south of Kasidaya Creek (Taiya Inlet area) (see Figure B-1).

Photo ID: EIT-03A. Typical zonation, including bands of *Fucus* and *Mytilus* on boulder beach, south of Kasidaya Creek (Taiya Inlet area) (see Figure B-1).

Photo ID: EIT-04. Extremely dense mussel beds on bedrock cliff (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-04A. Typical zonation, including bands of extremely dense *Mytilus*, *Fucus*, and barnacles on bedrock cliff (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-05. Extremely dense mussel beds on bedrock cliff (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-05A. Typical zonation, including bands of extremely dense *Mytilus* and *Fucus* on bedrock cliff (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-06. Typical zonation, including bands of extremely dense *Mytilus* and *Fucus* on boulder beach (Taiya Inlet area) (see Figure B-1).

Photo ID: EIT-06A. Typical zonation, including extremely dense mussel beds and bands of *Fucus* and barnacles on boulder beach (Taiya Inlet area) (see Figure B-1).

Photo ID: EIT-07. Typical zonation, including extremely dense mussel beds and bands of *Fucus* and barnacles on steep boulder beach leading to rock face (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-07A. Typical zonation, including bands of extremely dense *Mytilus* and *Fucus* on steep boulder beach leading to rock face (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-08. Southern view of cobble and gravel sediment beach showing less *Fucus* than EIT-4 through 7 (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-08A. Northern view of cobble and gravel sediment beach showing less *Fucus* than EIT-4 through 7 (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-09. Boulder shoreline exhibiting extensive mussel cover (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-09A. Boulder shoreline exhibiting extensive mussel cover (Taiya Inlet area) (see Figure B-1).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-10. Southern view of boulder and cobble shoreline (Chilkoot Inlet area) (see Figure B-3).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-10A. Steep boulder face along shoreline (Chilkoot Inlet area) (see Figure B-3).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-11. Typical zonation of boulder and cobble beach sites near the Katzehin River. Proposed ferry terminal site is to the south (Chilkoot Inlet area) (see Figures B-3 and B-4).

Photo ID: EIT-11A. Proposed ferry terminal site near the Katzehin River (Chilkoot Inlet area) (see Figures B-3 and B-4).

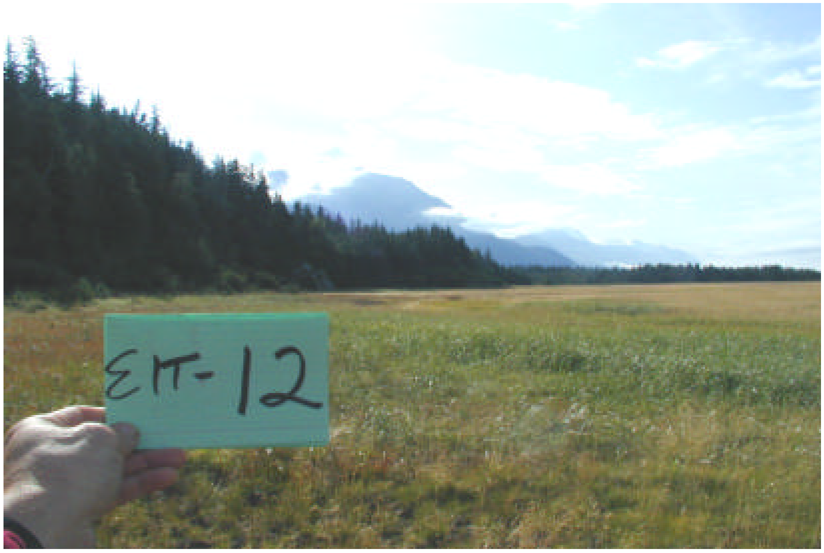

Photo ID: EIT-12. Wetland area, not intertidal. Grasses and sedges present throughout site, immediately north of the Katzehin River Delta (Chilkoot Inlet area) (see Figures B-3 and B-4).

Including one photo only for EIT-12 wetland site.

Photo ID: EIT-13. Sediment beach with gravel and clumps of *Fucus* on cobbles along beach. Tidal slough in background. South of the Katzehin River delta (Chilkoot Inlet area) (see Figure B-4).

Photo ID: EIT-13A. *Fucus* clumps on cobbles (Chilkoot Inlet area) (see Figure B-4).

Photo ID: EIT-14. View to the south of waterfall cutting through *Fucus* dominated cobble and sediment beach, near the Katzehin River delta (Chilkoot Inlet area) (see Figure B-4).

Photo ID: EIT-14A. Continuation of southern view of *Fucus* dominated sediment and cobble beach (Chilkoot Inlet area) (see Figure B-4).

Photo ID: EIT-15. Cobble and sediment beach, south of the Katzehin River delta (Chilkoot Inlet area) (see Figure B-4).

Note: There is one photo only for EIT-15. Alignment moved; this site no longer directly affected.

NOTE: Photos from the following sites were irretrievable from the digital camera: EIT-16, 17, and 18.

Photo ID: EIT-19. Boulder beach and bedrock cliffs with typical zonation (Lynn Canal area) (see Figure B-6).

Photo ID: EIT-19A. Overview of boulder beach (Lynn Canal area) (see Figure B-6).

Photo ID: EIT-20. Overview of boulder and cobble beach (Lynn Canal area) (see Figure B-6).

Photo ID: EIT-20A. Boulders and cobbles to the south (Lynn Canal area) (see Figure B-6).

Photo ID: EIT-21. Overview of long cobble and gravel beach (Lynn Canal area) (see Figure B-6).

Photo ID: EIT-21A. *Mytilus* and barnacle cover on boulders (Lynn Canal area) (see Figure B-6).

Photo ID: EIT-22. Bedrock cliffs and boulder beach with many mussel spat (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-22A. Continuation to the south of bedrock cliffs and boulder beach with many mussel spat (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-23. Typical zonation of *Fucus*, *Mytilus*, and barnacles on boulder beach (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-23A. Dogwinkle and limpet on boulder (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-24. Bedrock cliffs and boulder beach exhibiting typical zonation (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-24A. Coralline algae at waterline (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-25. Steep rock face at northernmost part of beach (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-25A. Slide area along shoreline (Lynn Canal area) (see Figure B-7).

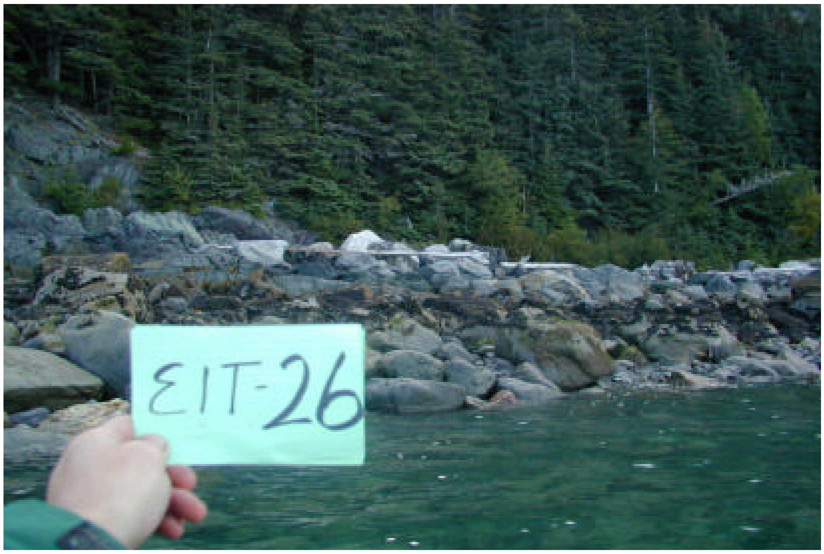

Photo ID: EIT-26. Boulder beach with steep outcrops (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-26A. Boulders covered with filamentous green algae and *Alaria* (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-27.   Gravel and cobble beach interspersed with cobbles (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-27A.   *Alaria* and coralline red algae on boulders (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-28. Rocky outcrop with boulders covered densely in coralline algae at waterline (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-28A. Rocky outcrop with boulders covered densely in coralline algae at waterline (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-29. Boulder beach (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-29A. Boulder beach with dense barnacles, yet minimal *Fucus* and *Alaria* (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-30. Boulder, cobble, and gravel beach (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-30A. Dense mussel spat on boulders (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-31. Boulder and cobble beach (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-31A. Green sea urchins, plate limpet, and coralline algae (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-32. Bedrock cliffs and boulders exhibiting typical zonation (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-32A. Continuation to the south of same short beach (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

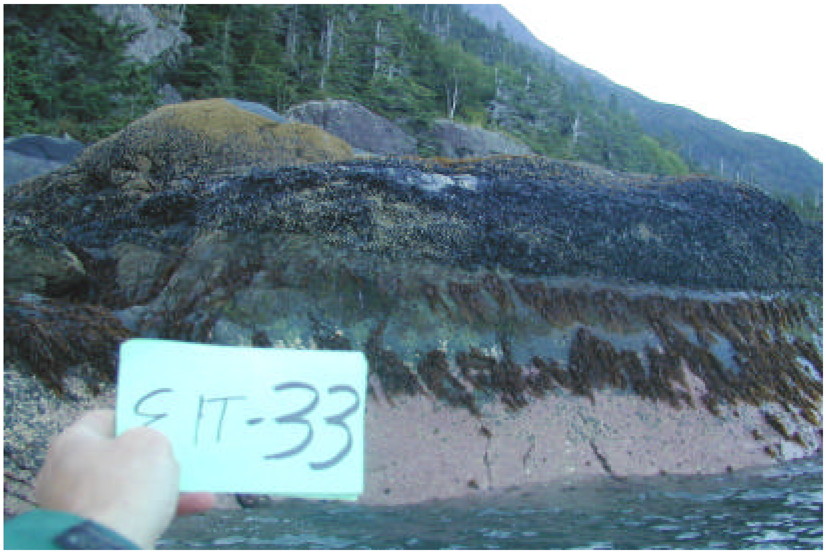

Photo ID: EIT-33. Short site, with rock and cliff face (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-33A. Short site, with rock and cliff face. Corraline algae coverage and typical zonation (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-34. Short site with bedrock cliffs and typical zonation (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-34A. Short site with bedrock cliffs and typical zonation (Lynn Canal area) (see Figure B-7).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-35. Moderately steep boulder beach exhibiting typical zonation (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-35A. Mottled sea star among green and purple sea urchins, *Mytilus*, and limpets (Lynn Canal area) (see Figure B-7).

Photo ID: EIT-36. Avalanche chute area and stream drainage to the north end of the site (Lynn Canal area) (see Figure B-8).

Photo ID: EIT-36A. View to the north of cobbles along the flat beach (Lynn Canal area) (see Figure B-8).

Photo ID: EIT-37. View to the north of cobbles along the flat beach. A small stream crosses the site, which has more diversity than site itself (Lynn Canal area) (see Figure B-8).

There is one photo only for EIT-37.

Photo ID: EIT-38. Boulder and cobble flat beach exhibiting typical zonation (Lynn Canal area) (see Figure B-8).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-38A. Site is located at the mouth of a fairly large and fast stream (Lynn Canal area) (see Figure B-8).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-39. Fairly exposed boulder and cobble beach with small patches of *Fucus* and *Mytilus* on boulders (Lynn Canal area) (see Figure B-8).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-39A. Large thatched barnacles on boulder (Lynn Canal area) (see Figure B-8).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-40. Low angle cobble beach located near Comet, with mine buildings visible in background (Lynn Canal area) (see Figure B-8).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-40A. Continuation of beach to the south (Lynn Canal area) (see Figure B-8).

Note: Alignment moved; this site no longer directly affected.

Note: EIT-41, the Lace River, was not surveyed so there are no photos.

Photo ID: EIT-42. Looking NE towards site EIT-42, Antler River at low tide (see Figure B-10).

Photo ID: EIT-42A. Attempting to reach site EIT-42, Antler River at low tide (see Figure B-10).

Photo ID: EIT-43. Slough with no apparent tidal influence (Berners Bay area) (see Figure B-10).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-43A. Slough with sandy bottom and small fish (Berners Bay area) (see Figure B-10).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-44. Slough with no apparent tidal influence (Berners Bay area) (see Figure B-10).

Note: Alignment moved; this site no longer directly affected.

Including one photo only for EIT-44.

Photo ID: EIT-45. Slough with tidal influence unlikely (Berners Bay area) (see Figure B-10).

Note: Alignment moved; this site no longer directly affected.

There is one photo only for EIT-45.

Photo ID: EIT-46. Tidally-influenced slough southeast of the Antler River. Sculpins and gunnels observed (Berners Bay area) (see Figure B-10).

Note: Alignment moved; this site no longer directly affected.

Photo ID: EIT-46A. *Enteromorpha* along bottom of slough (Berners Bay area) (see Figure B-10).

Photo ID: SLA-1. Rocky outcrop along shore exhibiting typical zonation at proposed ferry terminal site in Slate Cove (Berners Bay area) (see Figure B-9).

Photo ID: SLA-1A. *Fucus* clumps and *Mytilus* along proposed ferry terminal site in Slate Cove (Berners Bay area) (see Figure B-9).

Photo ID: WHB. William Henry Bay at low tide, near proposed ferry terminal site (see Figure B-12).

Photo ID: WHB-1. Long cobble/boulder beach with mussel beds in William Henry Bay, near proposed ferry terminal site (see Figure B-12).

ATTACHMENT B
SITE LOCATION MAPS

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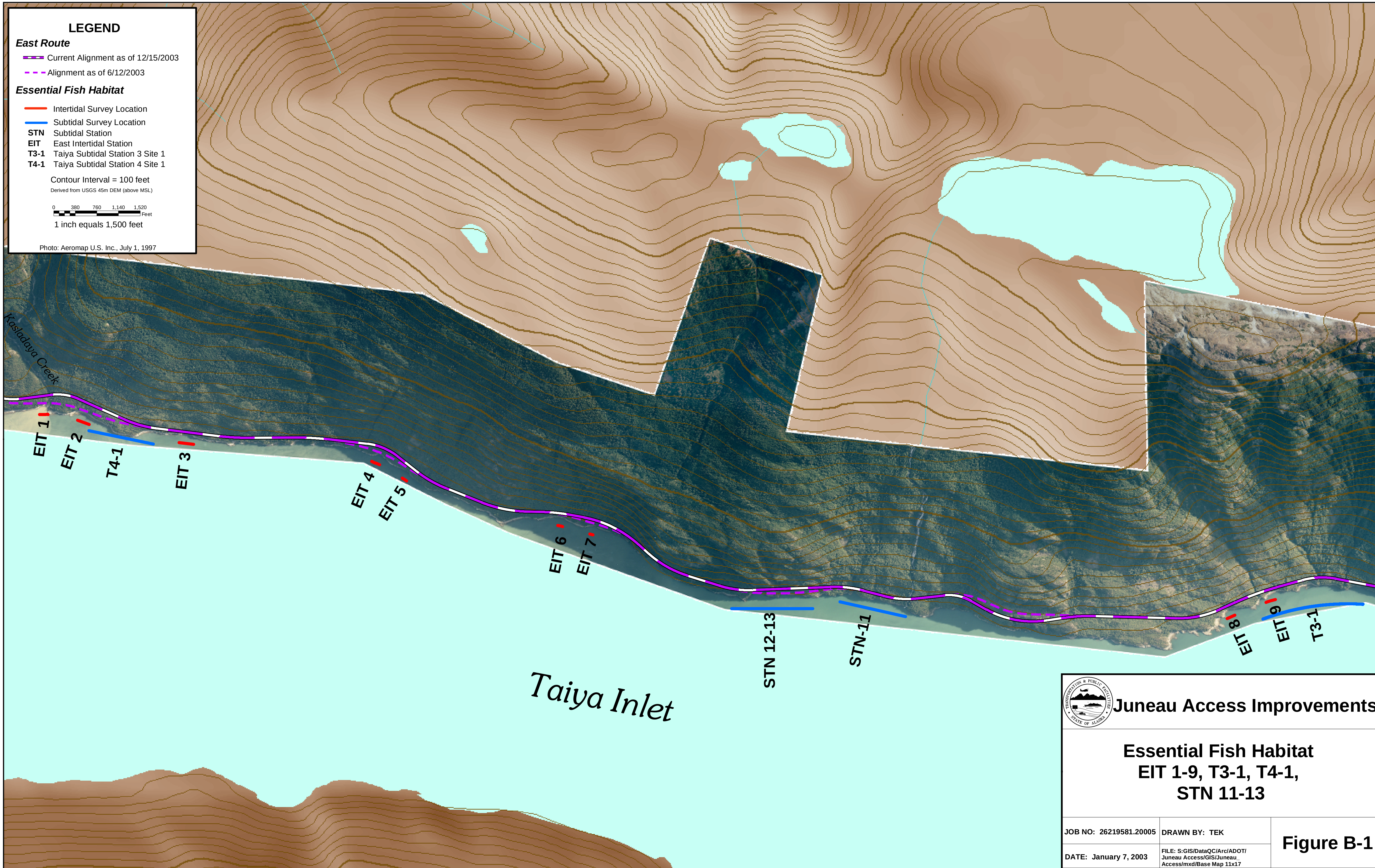

Juneau Access Improvements

Essential Fish Habitat EIT 1-9, T3-1, T4-1, STN 11-13

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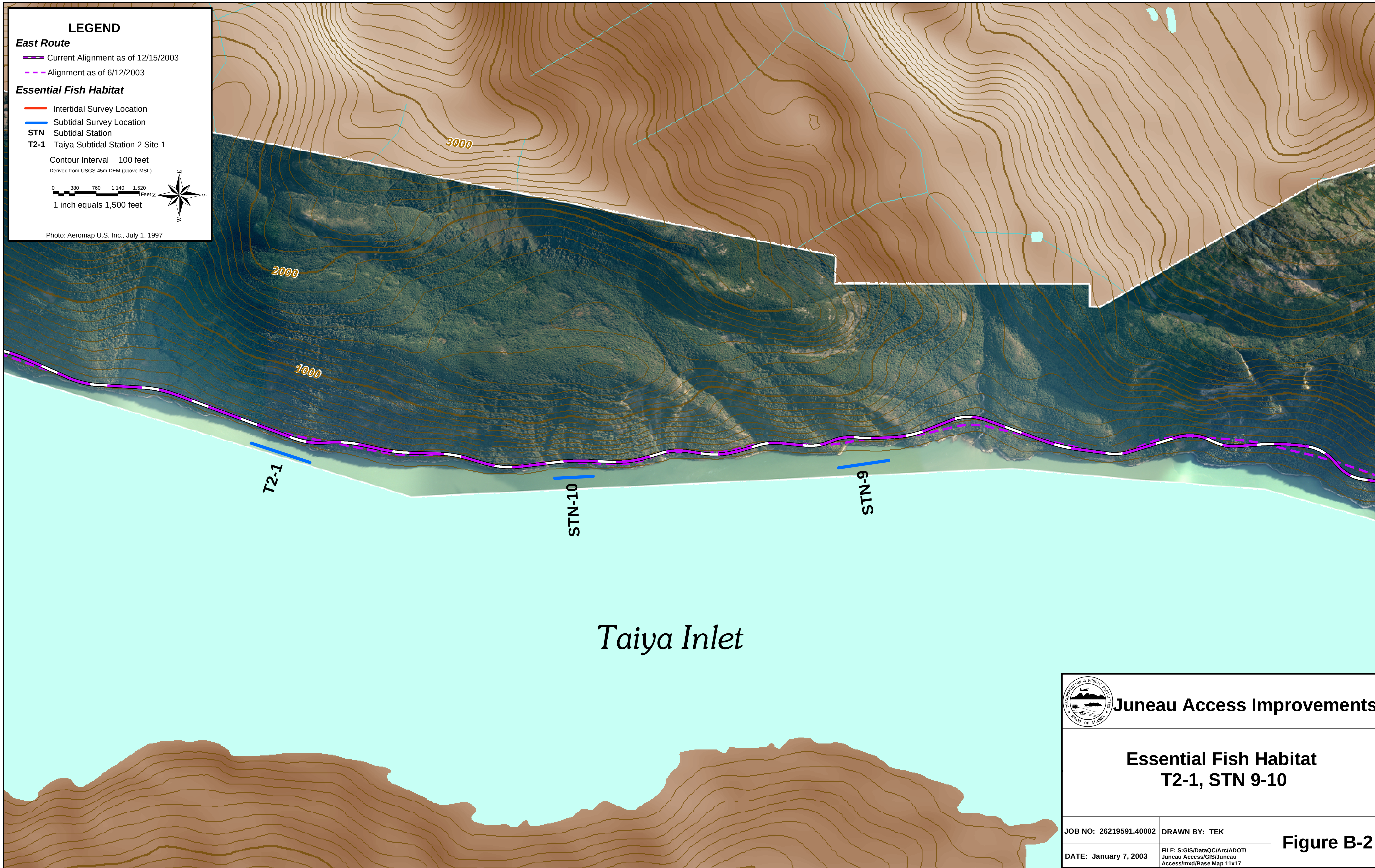

LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
STN Subtidal Station
T2-1 Taiya Subtidal Station 2 Site 1
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
3000
2000
1000
T2-1
STN-10
STN-9
Taiya Inlet
Juneau Access Improvements
Essential Fish Habitat
T2-1, STN 9-10
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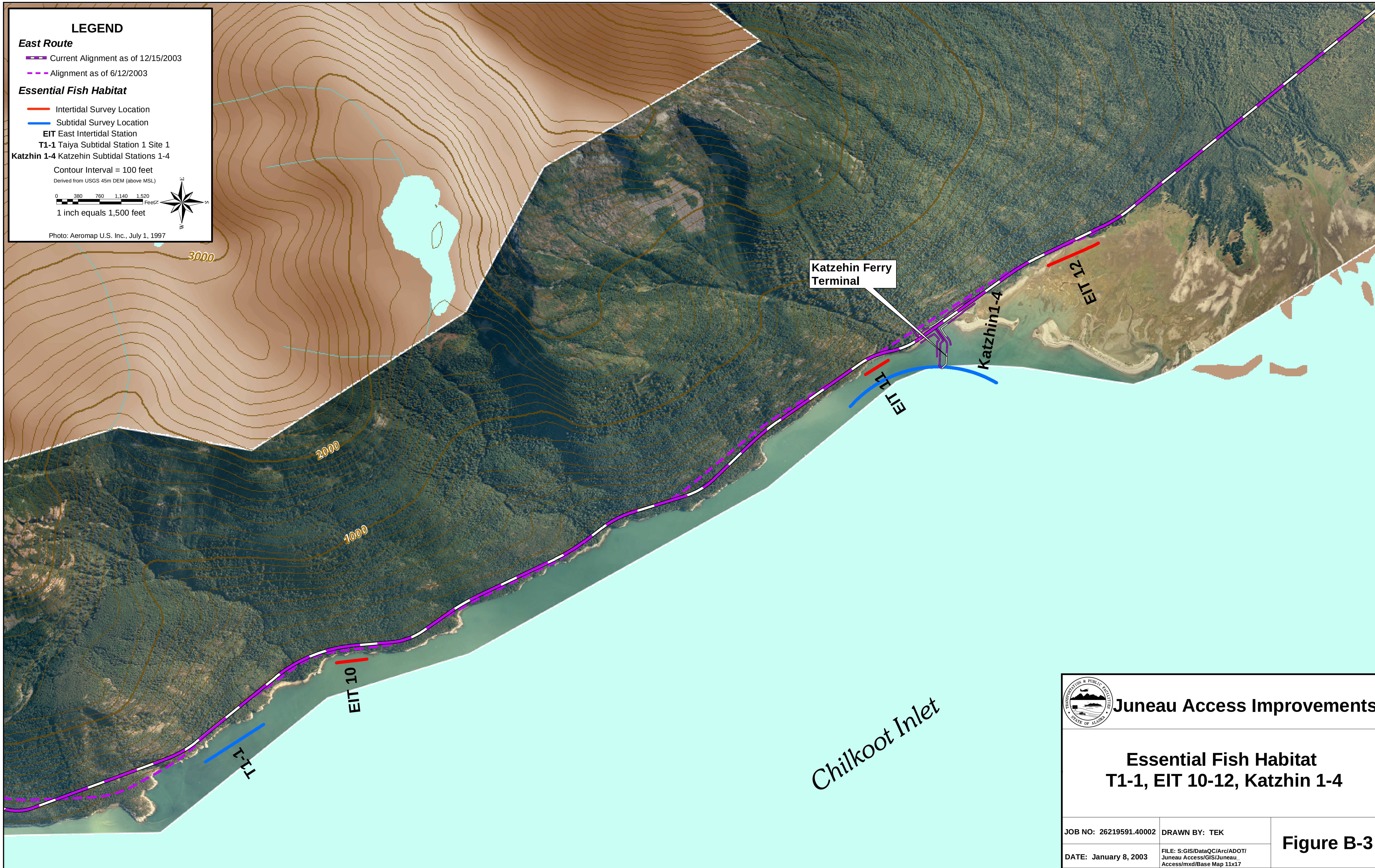
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East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
T1-1 Taiya Subtidal Station 1 Site 1
Katzhin 1-4 Katzehin Subtidal Stations 1-4
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
3000
2000
1000
Katzehin Ferry Terminal
Katzhin1-4
EIT 12
EIT 11
EIT 10
T1-1
Chilkoot Inlet
Juneau Access Improvements
Essential Fish Habitat
T1-1, EIT 10-12, Katzhin 1-4
JOB NO: 26219591.40002
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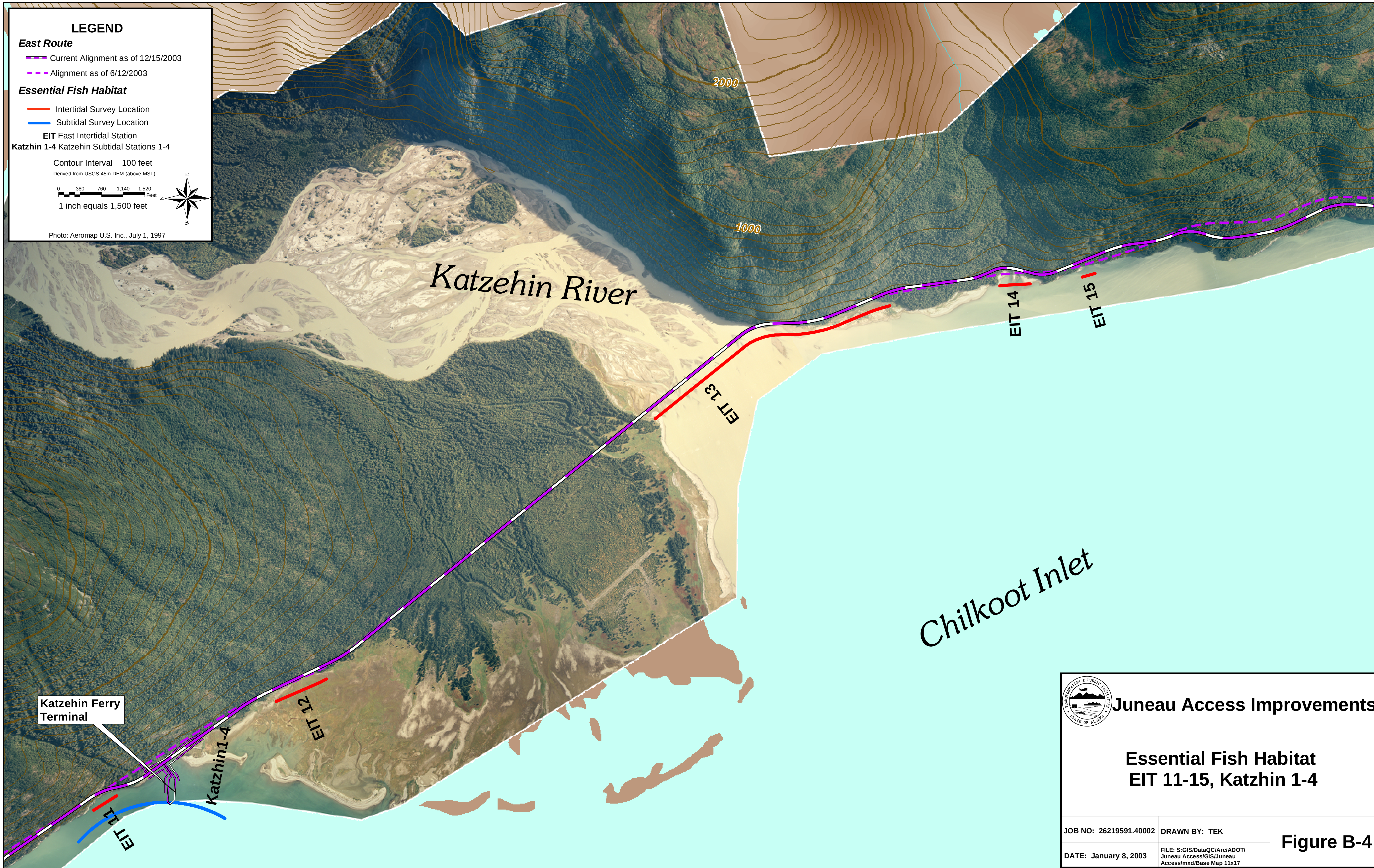
Figure B-3



LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
Katzhin 1-4 Katzehin Subtidal Stations 1-4
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
2000
1000
Katzehin River
Chilkoot Inlet
Katzehin Ferry Terminal
Katzhin1-4
EIT 11
EIT 12
EIT 13
EIT 14
EIT 15
Juneau Access Improvements
Essential Fish Habitat
EIT 11-15, Katzhin 1-4
JOB NO: 26219591.40002
DRAWN BY: TEK
DATE: January 8, 2003
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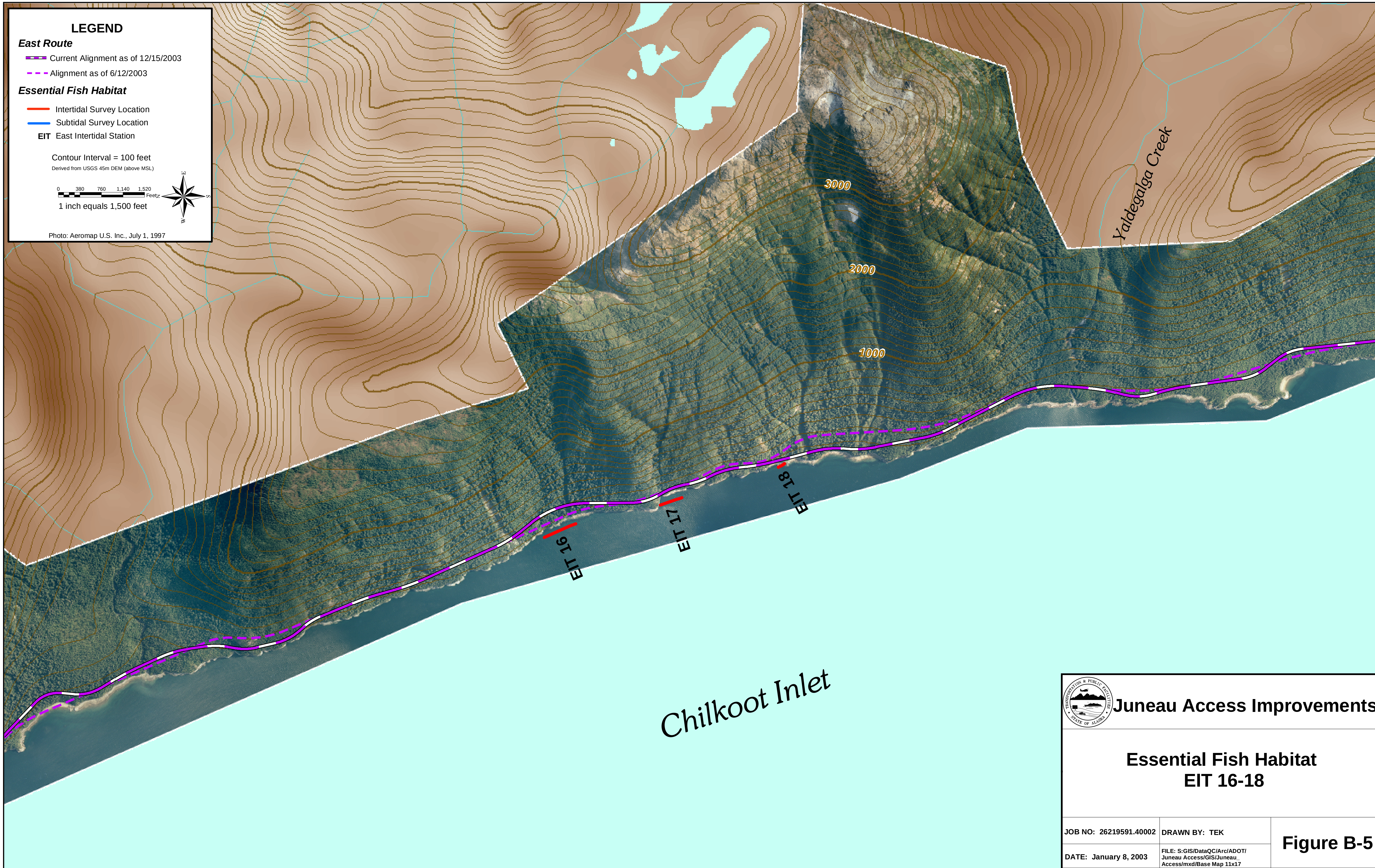
LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
3000
2000
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Yaldegalga Creek
EIT 16
EIT 17
EIT 18
Chilkoot Inlet
Juneau Access Improvements
Essential Fish Habitat
EIT 16-18
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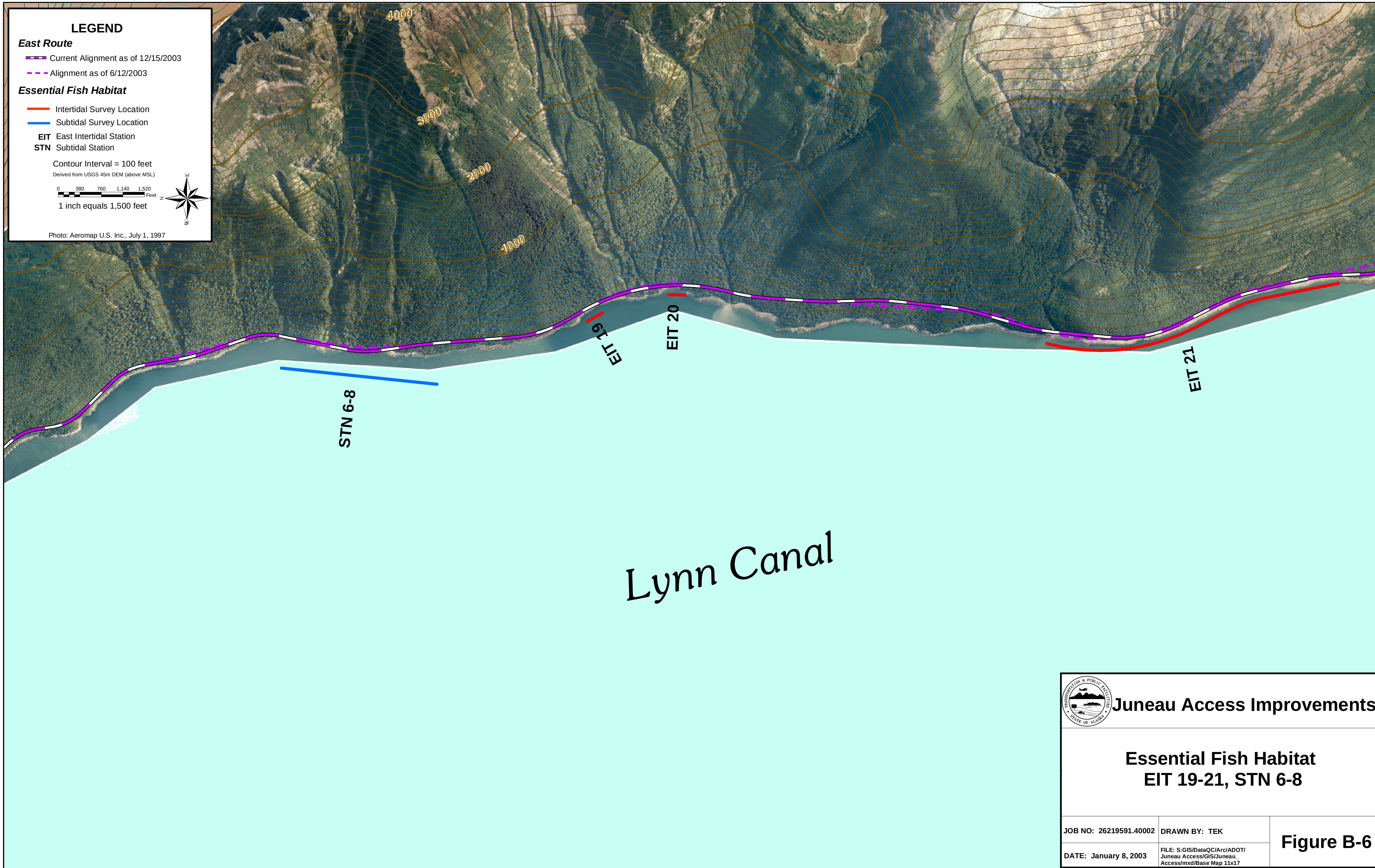
Figure B-5


LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
STN Subtidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
4000
3000
2000
1000
EIT 19
EIT 20
EIT 21
STN 6-8
Lynn Canal
Juneau Access Improvements
Essential Fish Habitat
EIT 19-21, STN 6-8
JOB NO: 26219591.40002
DRAWN BY: TEK
DATE: January 8, 2003
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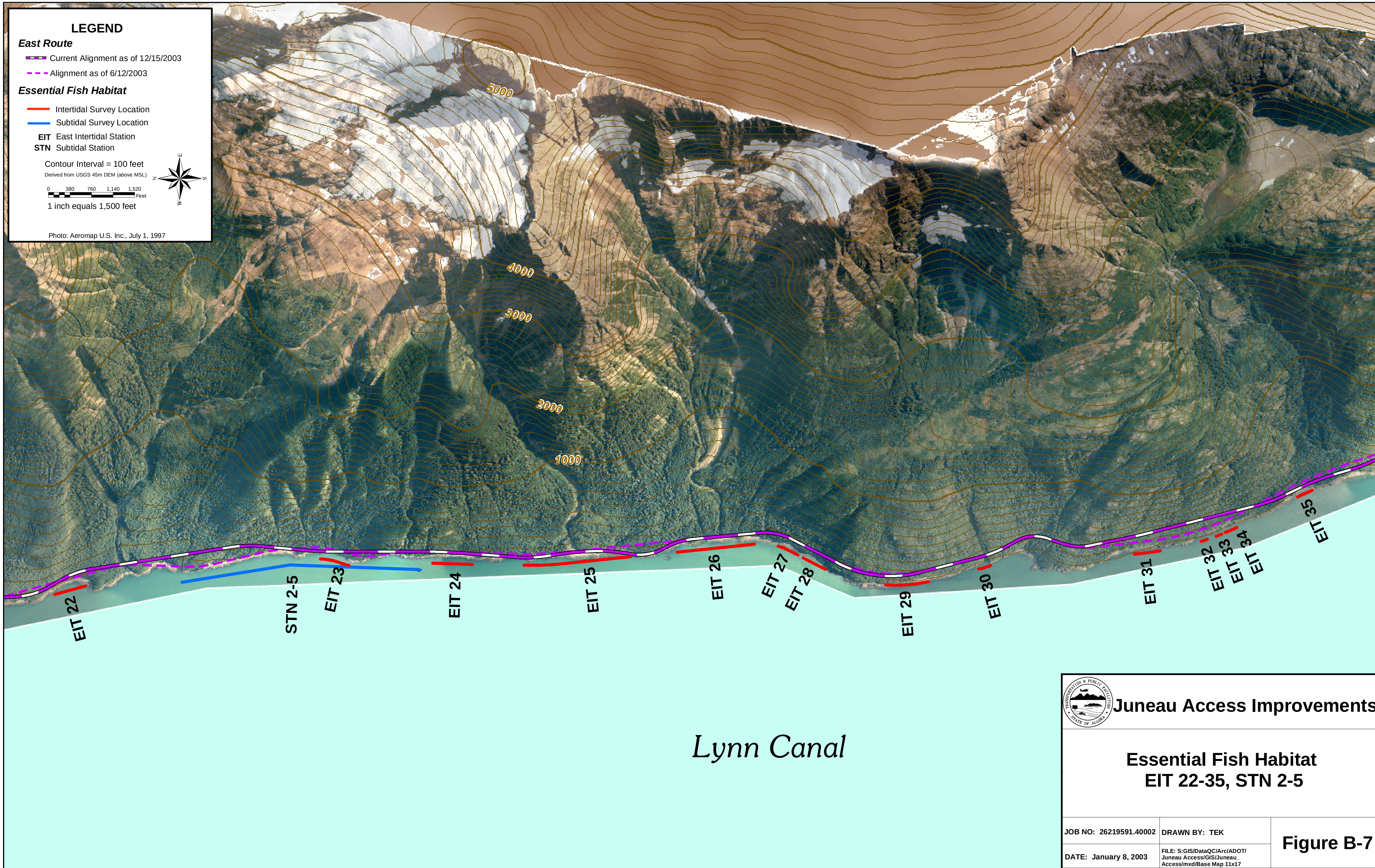

LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
STN Subtidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
5000
4000
3000
2000
1000
EIT 22
STN 2-5
EIT 23
EIT 24
EIT 25
EIT 26
EIT 27
EIT 28
EIT 29
EIT 30
EIT 31
EIT 32
EIT 33
EIT 34
EIT 35
Lynn Canal
Juneau Access Improvements
Essential Fish Habitat
EIT 22-35, STN 2-5
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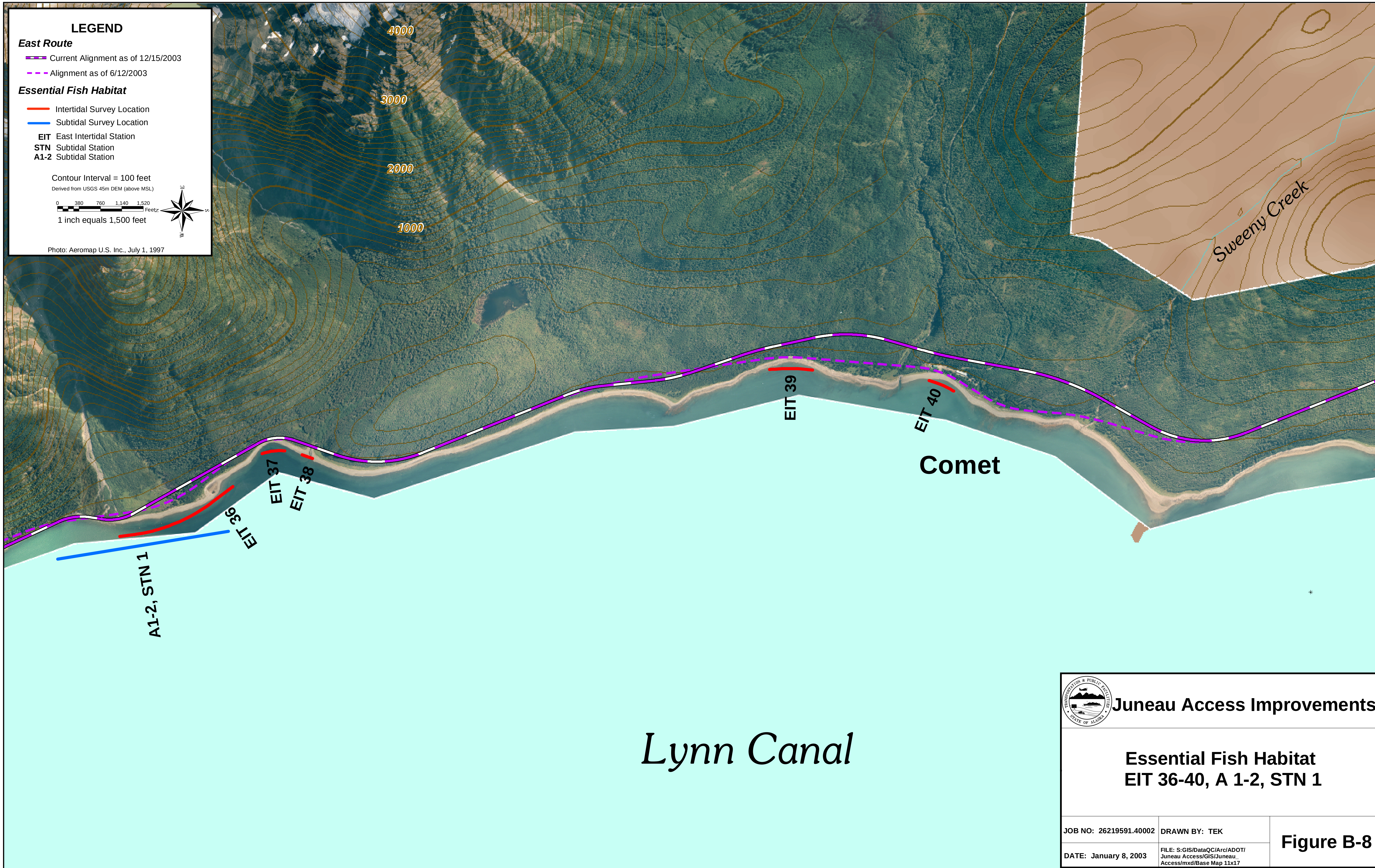
LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
STN Subtidal Station
A1-2 Subtidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
4000
3000
2000
1000
Sweeny Creek
EIT 36
EIT 37
EIT 38
EIT 39
EIT 40
A1-2, STN 1
Comet
Lynn Canal
Juneau Access Improvements
Essential Fish Habitat
EIT 36-40, A 1-2, STN 1
JOB NO: 26219591.40002
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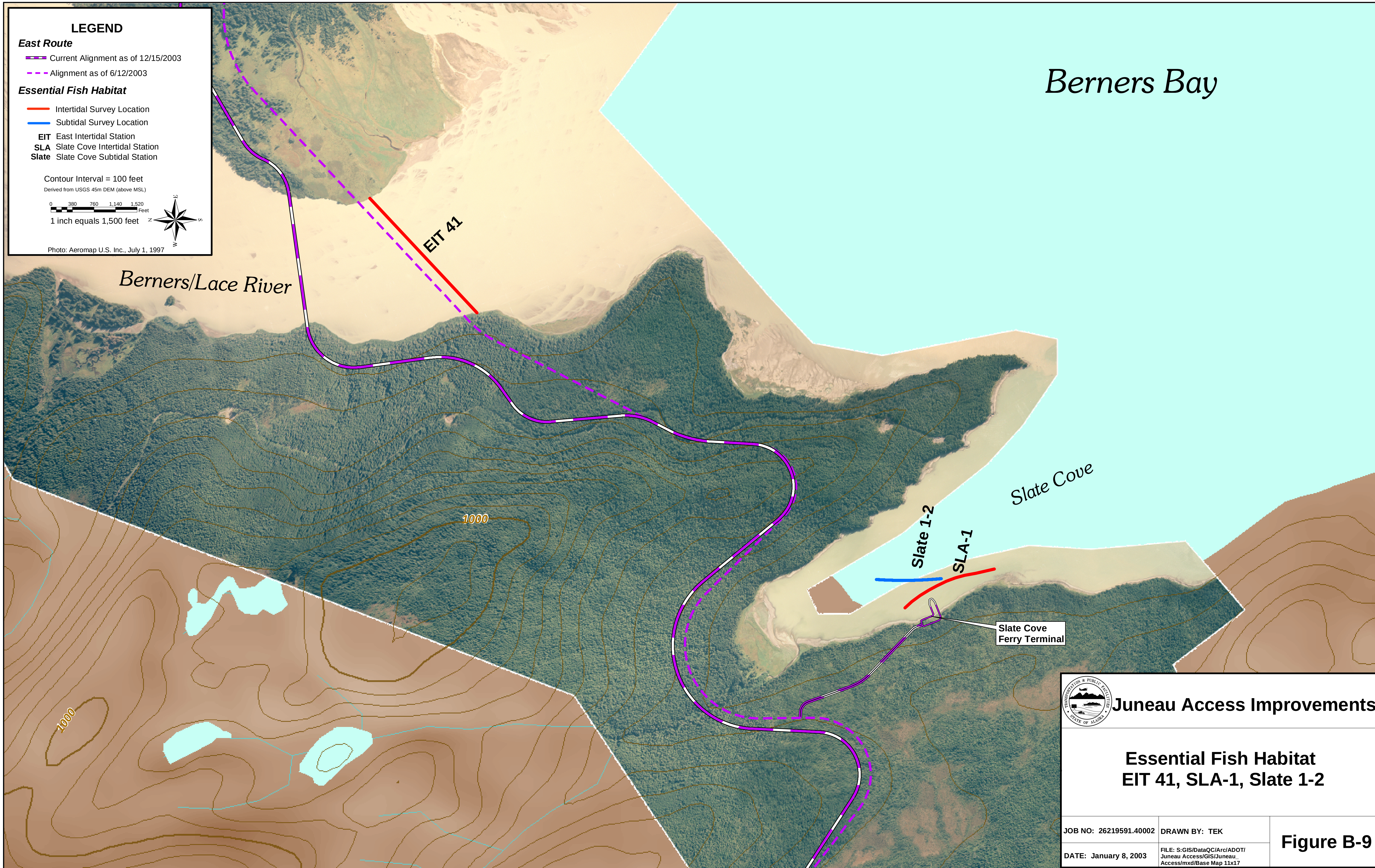
LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
SLA Slate Cove Intertidal Station
Slate Slate Cove Subtidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
Berners Bay
Berners/Lace River
EIT 41
Slate Cove
Slate 1-2
SLA-1
1000
1000
Slate Cove Ferry Terminal
Juneau Access Improvements
Essential Fish Habitat
EIT 41, SLA-1, Slate 1-2
JOB NO: 26219591.40002
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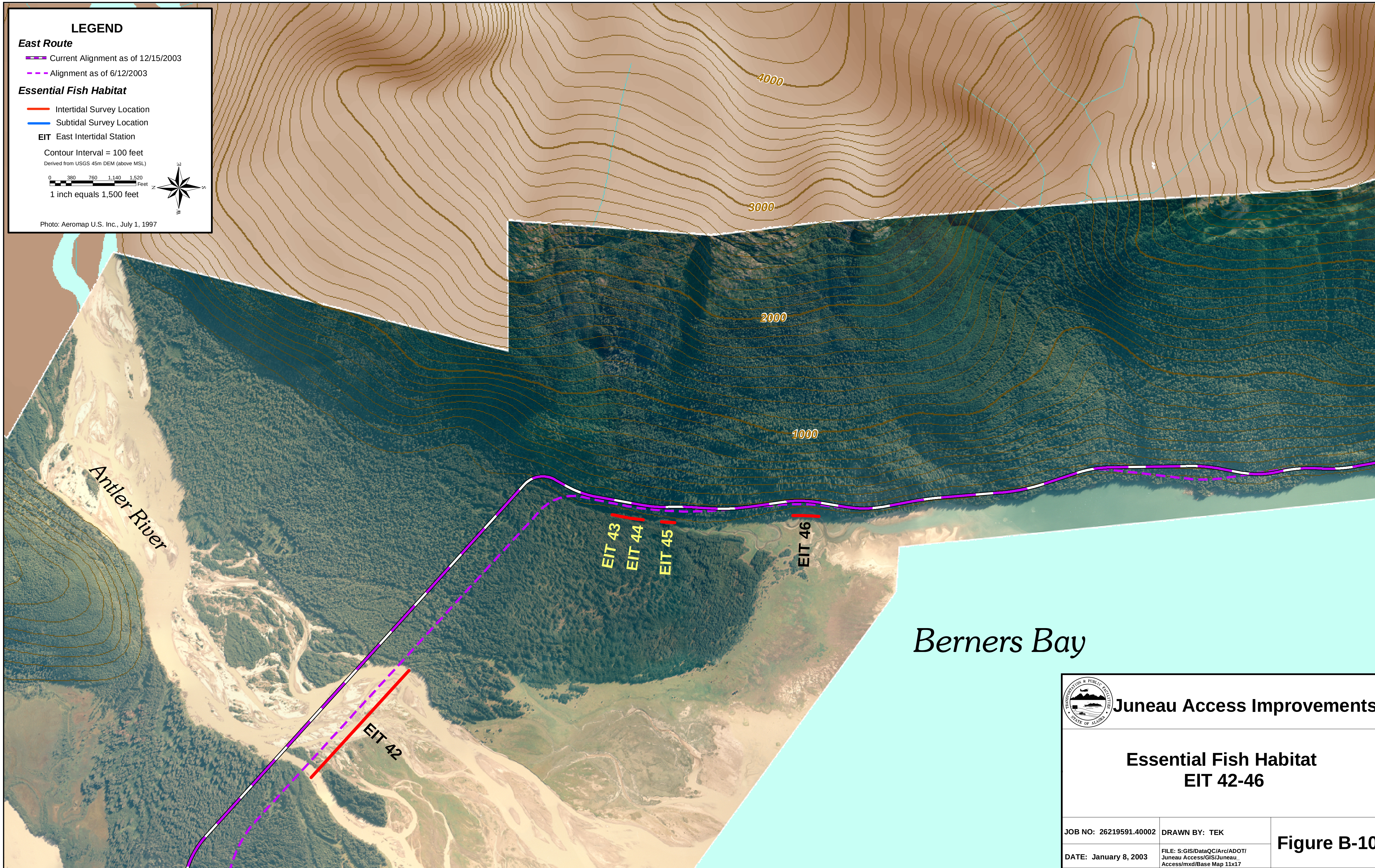
LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
EIT East Intertidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
4000
3000
2000
1000
Antler River
Berners Bay
EIT 42
EIT 43
EIT 44
EIT 45
EIT 46
Juneau Access Improvements
Essential Fish Habitat
EIT 42-46
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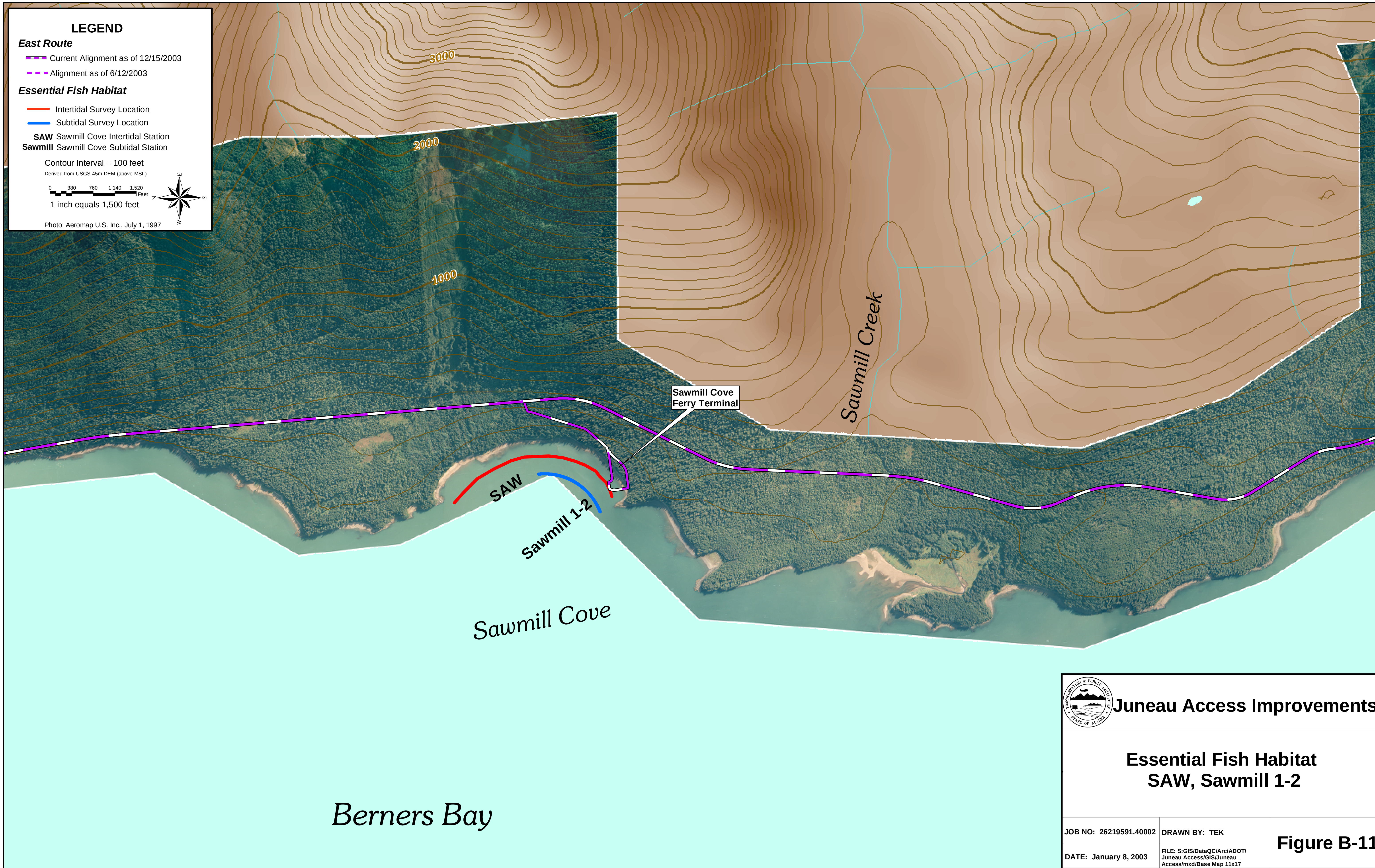
LEGEND
East Route
Current Alignment as of 12/15/2003
Alignment as of 6/12/2003
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
SAW Sawmill Cove Intertidal Station
Sawmill Sawmill Cove Subtidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520 Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., July 1, 1997
3000
2000
1000
Sawmill Creek
Sawmill Cove Ferry Terminal
SAW
Sawmill 1-2
Sawmill Cove
Berners Bay
Juneau Access Improvements
Essential Fish Habitat
SAW, Sawmill 1-2
JOB NO: 26219591.40002
DRAWN BY: TEK
DATE: January 8, 2003
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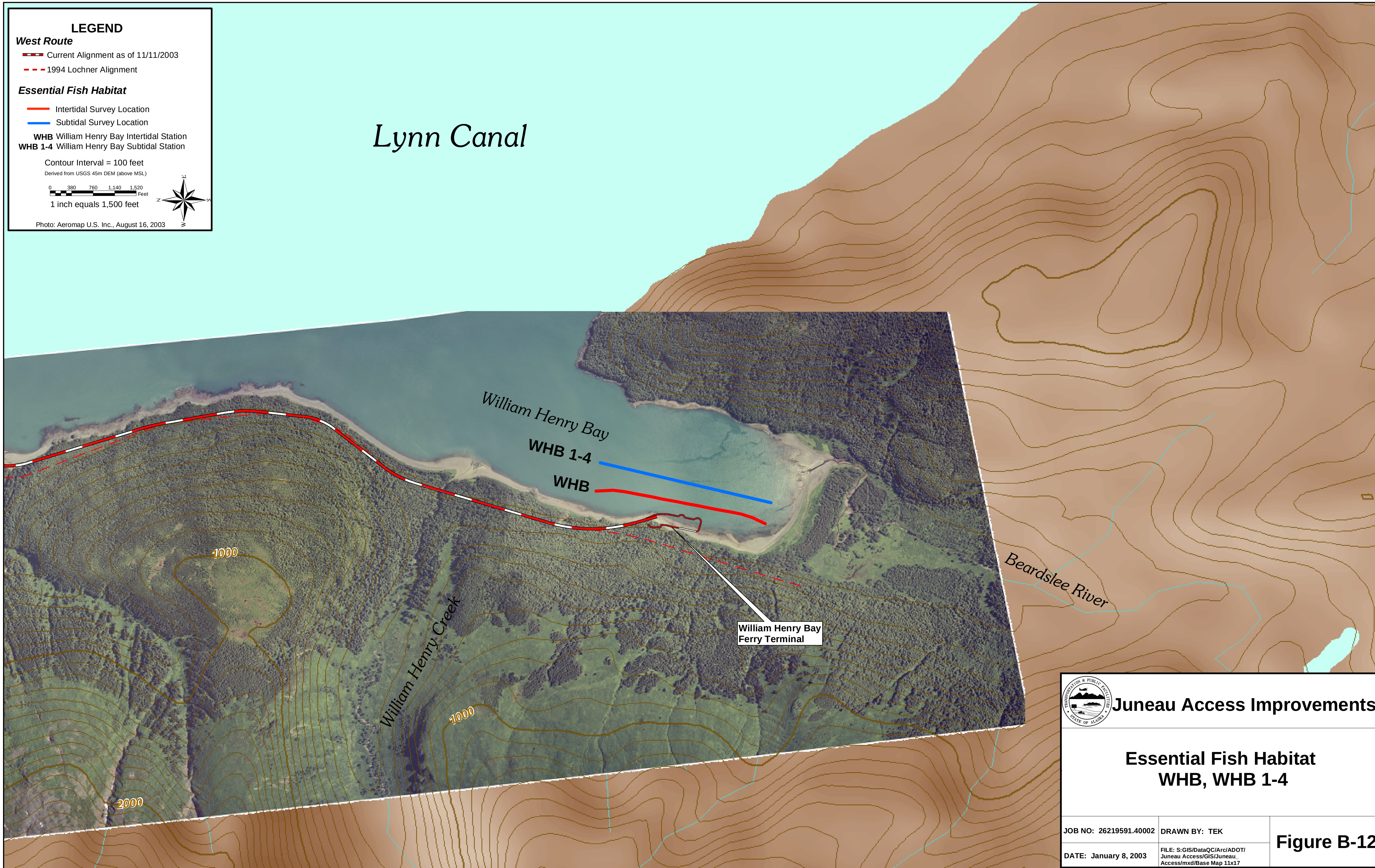
Figure B-11


LEGEND
West Route
Current Alignment as of 11/11/2003
1994 Lochner Alignment
Essential Fish Habitat
Intertidal Survey Location
Subtidal Survey Location
WHB William Henry Bay Intertidal Station
WHB 1-4 William Henry Bay Subtidal Station
Contour Interval = 100 feet
Derived from USGS 45m DEM (above MSL)
0 380 760 1,140 1,520
Feet
1 inch equals 1,500 feet
Photo: Aeromap U.S. Inc., August 16, 2003
Lynn Canal
William Henry Bay
WHB 1-4
WHB
William Henry Bay
Ferry Terminal
Beardslee River
William Henry Creek
1000
1000
2000
Juneau Access Improvements
Essential Fish Habitat
WHB, WHB 1-4
JOB NO: 26219591.40002
DRAWN BY: TEK
DATE: January 8, 2003
FILE: S:GIS/DataQC/Arc/ADOT/
Juneau Access/GIS/Juneau_
Access/mxd/Base Map 11x17
Figure B-12

ATTACHMENT C
FORAGE FISH EVALUATION

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PNWD-3419

Reconnaissance Evaluation of Ecological Effects to Forage Fish Populations Associated With the Juneau Access Improvements Project

G. D. Williams
L. K. O'Rourke
W. H. Pearson

Battelle Marine Sciences Laboratory
Sequim, Washington

October 2004

Prepared for

URS Corporation
8411 Airport Blvd
Juneau, Alaska 99801

Battelle, Pacific Northwest Division
of Battelle Memorial Institute

Battelle
The Business of Innovation

PNWD-3419

Reconnaissance Evaluation of Ecological Effects to Forage Fish Populations Associated With the Juneau Access Improvements Project

Gregory D. Williams
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Walter H. Pearson

Battelle Marine Sciences Laboratory
Sequim, Washington

October 2004

Prepared for

URS Corporation
8411 Airport Blvd
Juneau, Alaska 99801

Battelle Memorial Institute
Pacific Northwest Division
Richland, Washington 99352

Executive Summary

This technical report is intended to serve as a supporting document to the Juneau Access Improvements Supplemental Draft Environmental Impact Statement (SDEIS), Essential Fish Habitat (EFH) Assessment Technical Report, which will use the results of this report to evaluate the potential impacts of the specific project alternatives. We assess the status of the current Pacific herring and eulachon populations in Lynn Canal, including possible causes for the decline in the herring population. We also identify potential stressors associated with typical coastal highway and marine transportation facilities on Pacific herring and eulachon, and assess the likely ecological effects of those stressors on these fish populations.

We emphasize that this technical report, in its role as a supporting document to the SDEIS EFH Assessment Technical Report, provides general guidance as to how typical project activities may affect Pacific herring and eulachon populations based on the existing literature. Therefore, we do not delve deeply into the more likely risks associated with specific project alternatives, and refer readers to the EIS document which provides an assessment of risk based on detailed knowledge of the project alternatives.

Our technical approach parallels guidelines established by the U.S. Environmental Protection Agency for assessing ecological risks. This paper concentrates on problem formulation, specifically the characterization of exposure to potential stressors and likely effects. Methods involved a thorough literature review and a series of interviews with local scientists to gather available information, which was analyzed as follows. Life-history information was integrated into a conceptual model that clarified the distribution and use of various habitats by species' life-history stage. Findings from other studies were used to clarify further the primary stressors that affect eulachon and herring at the organism and population levels and identified pathways by which typical highway and marine transportation facilities could impact Pacific herring and eulachon. We used our best professional judgment to determine how typical project activities may affect Pacific herring and eulachon populations in Lynn Canal.

The Pacific herring stock in Lynn Canal has been in a state of decline since the 1970s, with current estimates suggesting that the population of mature adult fish has fallen to near 1000 tons. Furthermore, the linear area (miles) of Pacific herring spawning activity has been reduced to a fraction of its historic extent. The Lynn Canal herring fishery has been closed for over 20 years without recovery, suggesting that factors other than harvesting are now influencing the population and may be inhibiting growth to previous levels.

Eulachon stock assessments have not been formally conducted in southeast Alaska, and the status of eulachon populations is primarily based on anecdotal evidence or trends from other regions, which suggest long-term declines in run biomass.

Various hypotheses have been put forward as to why Lynn Canal herring stocks and Pacific coast runs of eulachon have declined, although none have been substantiated through careful scientific analysis. These hypotheses include one or some combination of the following factors: overfishing, increased predator populations, disease, habitat alteration or degradation, water pollution, and unfavorable oceanographic conditions.

Pacific herring and eulachon populations are recognized as critical links in the marine food web and viewed as necessary to ensure healthy populations of predatory fish, marine birds, and marine mammals. They are also important to commercial, personal use, and subsistence (traditional use) harvesters. Both Pacific herring and eulachon have life-history stages that make them vulnerable to a variety of environmental hazards, in particular to shore-based activities from which impacts extend into shorelines,

nearshore areas, and lower-river reaches. Potential stressors identified from the literature that have impacted herring and eulachon stocks in other systems include fishing/harvest, impaired water quality (PAH, other contaminants, nutrients, turbidity, altered salinity/temperature), habitat alteration, human disturbance, disease, increased predation, decreases in prey, ocean climate, and stochastic processes.

In general, project actions that affect the quality or spatial extent of documented spawning habitats along shorelines (Pacific herring) or lower river channels (eulachon) represent the highest likelihood for ecological impacts to these forage fish populations. Both Pacific herring and eulachon are highly dispersed in marine waters throughout most of their life history, but congregate in spawning habitats during a short period of time in the spring. This makes spawning adults and early life history stages vulnerable to shore-based activities that impact shorelines, nearshore areas, and lower-river reaches.

Berners Bay is the current center of spawning activity for declining Lynn Canal herring stocks. Thus, activities that occur along the shoreline or in the nearshore region of Berners Bay could result in the loss or degradation of historically documented herring spawning habitat. Likewise, marine traffic activities in documented pre-spawn schooling areas (e.g. Slate Creek Cove) could impede eulachon spawning.

Bridge construction, maintenance, and use in the lower reaches of several rivers (e.g., Berners, Lace, Antler, Katzehin, and Chilkat Rivers) has the potential to degrade documented eulachon spawning habitats. Most highway construction impacts could be minimized by avoiding time periods when spawning and egg incubation occurs. Bridge structures that affect river hydrology, hydraulics (i.e., velocity barriers), channel morphology, or substrate composition could have chronic indirect effects to spawning areas, although it is unclear from the literature how substantial changes in river bottom substrate may affect the long-term viability of eulachon spawning habitat.

Most of our conclusions about potential effects focused on alteration of forage-fish spawning habitat, in part, because these impacts are readily translated into estimates of lost reproductive potential. Therefore, actions that directly impact spawning habitats can most easily be predicted and avoided. Few other effects are as easy to translate into population-level effects. Other indirect effects, such as water quality contamination or human disturbance, are more difficult to predict given the uncertainties of runoff composition, concentration, and mixing rates, although they could have negative effects if they occurred at the wrong time. Data gaps that inhibited our ability to confidently predict the indirect effects associated with typical highway and marine transportation facilities include current information on the marine distribution of eulachon and herring populations in Lynn Canal and eulachon run size and stock trends.

Acronyms

AADT	annual average daily traffic
ADF&G	Alaska Department of Fish and Game
ASA	age structured analysis
BMPs	best management practices
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DOT&PF	Alaska Department of Transportation and Public Facilities
EPA	U.S. Environmental Protection Agency
MESA	most environmentally sensitive areas
NMFS	National Marine Fisheries Service
PAH	polynuclear aromatic hydrocarbons
PAR	photosynthetically active radiation
PWS	Prince William Sound
ROV	remotely operated vehicle
SDEIS	Supplemental Draft Environmental Impact Statement
SSB	spawning stock biomass
TIA	total impervious area
TPAH	total polynuclear aromatic hydrocarbons
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VEN	viral erythrocytic necrosis
VHSV	viral hemorrhagic septicemia virus
WSF	water-soluble fractions
YOY	young-of-the-year

Contents

Figures

Tables

1.0 Introduction

1.1 Project Description

The Juneau Access Improvements Project is currently evaluating various alternatives to improve surface transportation between Juneau and Haines/Skagway in the Lynn Canal corridor in southeast Alaska. The range of reasonable alternatives includes highways on either side of Lynn Canal, as well as additional ferry service that would involve new ferry terminals in various locations (see Supplemental Draft Environmental Impact Statement [SDEIS] for full project alternative descriptions).

1.2 Purpose of Report

Resource agencies have expressed concern that proposed Juneau Access Improvements Project alternatives have the potential to affect Pacific herring (*Clupea pallasi*) and eulachon (*Thaleichthys pacificus*) populations in the vicinity of Lynn Canal. In particular, agency representatives have cited the need to address potential impacts of project alternatives to the Lynn Canal herring stock. Although ecosystem effects are not specifically addressed here, Pacific herring and eulachon are ecologically and commercially important forage-fish species that are dependent on healthy nearshore areas or coastal inlets and streams for spawning. Both are prey species for a variety of fish, mammals, and birds, and are also harvested by humans for commercial, personal, and subsistence use.

This technical report is intended to serve as a supporting document to the Juneau Access Improvements Supplemental Draft Environmental Impact Statement (SDEIS), Essential Fish Habitat (EFH) Assessment Technical Report, which will use the results of this report to evaluate the potential impacts of the specific project alternatives. We assess the status of the current Pacific herring and eulachon populations in Lynn Canal, including possible causes for the decline in the herring population. We also identify potential stressors associated with *typical* coastal highway and marine transportation facilities on Pacific herring and eulachon, and assess the likely ecological effects of those stressors on these fish populations.

We emphasize that this technical report, in its role as a supporting document to the SDEIS EFH Assessment Technical Report, provides general guidance as to how typical project activities may affect Pacific herring and eulachon populations based on the existing literature. Therefore, we do not delve deeply into the more likely risks associated with specific project alternatives, and refer readers to the EIS document which provides an assessment of risk based on detailed knowledge of the project alternatives. We assume that the EIS will clarify where specific project activities do not conform to the typical conditions outlined in this report. Furthermore, we expect the EIS will use current maps of the proposed highway and marine alternatives with herring and eulachon spawning areas in Lynn Canal (provided in this document) to discern the pathways by which construction activities and operations could render the two resources potentially vulnerable to effects.

2.0 Approach

Our technical approach parallels guidelines established by the U.S. Environmental Protection Agency (EPA) for assessing ecological risk. Ecological risk assessment is generally based on characterization of two major elements: exposure and effects (EPA 1998) (Figure 1). These elements are the focus for conducting the three phases of risk assessment: problem formulation, analysis, and risk characterization.

Our technical paper concentrates on the first two phases, problem formulation and analysis, in support of the third phase, risk characterization, being done in the EFH Assessment Technical Report and other SDEIS documents.

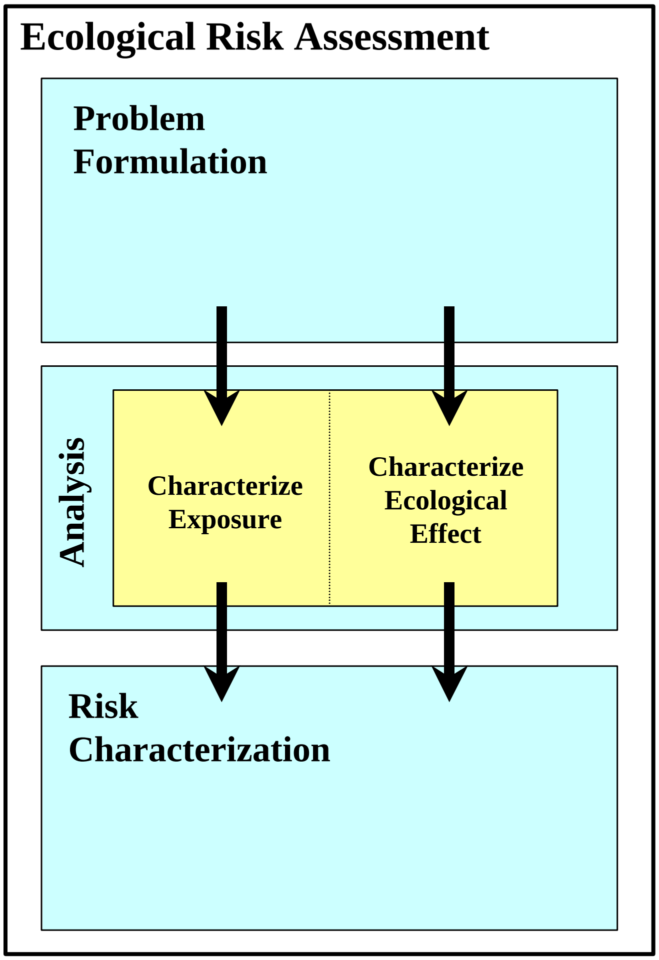

Figure 1. The framework for ecological risk assessment (modified from EPA 1998)

Problem formulation was guided by a literature review and a series of interviews with scientists who had a working knowledge of forage-fish stocks in the region (Table 1). Relevant reports, published scientific papers, and other literature related to general Pacific herring and eulachon ecology and stock status were compiled and reviewed for relevance to the project. Personal interviews were conducted in Juneau with a number of scientists identified by DOT&PF as having considerable knowledge of regional herring and eulachon populations. Initial interviews were used to gather anecdotal and unpublished information relevant to the project, as well as to identify additional sources of local knowledge for follow-up interviews, either in person or by telephone or e-mail.

Table 1. Individuals Contacted for Information

Name	Affiliation	Primary Contact	Topics
Kevin Monagle	ADF&G	phone	Lynn Canal herring stocks and management
Dave Harris	ADF&G	person to person	Lynn Canal herring stocks
Marc Pritchett	ADF&G	person to person	Herring stock management
Jeff Short	NMFS	person to person	Toxicology, herring reproductive habitat & vulnerabilities
Mark Carls	NMFS	person to person	Toxicology, reproductive habitat
Ron Heintz	NMFS	person to person	Toxicology, reproductive habitat
Carl Schrader	DNR OHMP	person to person	Potential habitat impacts of project
Richard Enriquez	USFWS	person to person	Habitat issues, Berners Bay ecosystem
Ed Grossman	USFWS	person to person	Habitat issues, Berners Bay
Don Martin	USFS	person to person	Land use, Eulachon stocks
Rob Spangler	USFS	phone	Eulachon in Berners Bay
Mike Sigler	NMFS	person to person	Hydroacoustic surveys, food web interactions, predators
Bruce Wing	NMFS	person to person	Oceanographic conditions
Susan Walker	NMFS	phone, e-mail	Land use changes in Auke Bay
Randy Bachman	ADF&G	phone	Eulachon stocks in northern Lynn Canal
Mike Turek	ADF&G	phone, e-mail	Subsistence use of eulachon
Brian Marston	ADF&G	e-mail	Eulachon ecology and status

We analyzed available information to distinguish assessment endpoints, exposure pathways, and ecological effects of activities associated with typical highway and marine transportation facilities. To accomplish this, we described the general ecology and distribution of Lynn Canal herring and eulachon populations, summarized their use of various habitats by life history stage, and integrated this information into a conceptual model (Section 3.0). We then used findings from other studies to clarify stressors that may affect eulachon and Pacific herring at the organism and population level (Section 4.0). The general characteristics of typical highway and marine ferry terminal facilities were summarized, pathways of exposure for Pacific herring and eulachon were identified, and best professional judgment was used to assess the likely ecological effects of these alternatives (Section 5.0). Finally, using the chain of logic developed in the previous sections, we present an overview of the most likely risks to forage fish in Lynn Canal (Section 6.0) and summarize our conclusions (Section 7.0).

3.0 Problem Formulation – Description of Resources at Risk

3.1 Herring

3.1.1 General Life History and Ecology

Pacific herring, *Clupea pallasi*, inhabit continental shelf regions and spend much of their lives in nearshore waters (Carlson 1980; Hay 1985). Mature herring generally spawn in the spring in Alaska with spawning times ranging from mid-March in southeast Alaska to June in the Bering Sea (ADF&G 1994). As perhaps an adaptation to minimize egg loss, herring spawn in inlets, bays, sounds, and estuaries that are somewhat sheltered from open coastline surf (Emmet et al. 1991; Haegele and Schweigert 1985). Herring are annual spawners upon reaching maturity and spawn in the same general locations every year (Emmet et al. 1991; Hay and Outram 1981 in Lassuy 1989). Extensive tagging studies indicate that

Pacific herring fidelity rates (a process biologically different than homing, and defined in this study as the proportion of tags recovered in the same area as released) are high for large geographic areas (e.g., Strait of Georgia) but lower for small areas, such as inlets or bays (Hay et al. 2001).

Factors that initiate spawning are not well understood (Haegele and Schweigert 1985). In northern latitudes, spawning appears to be synchronized with an increase in water temperature to ensure adequate incubating conditions. Tides may also play a role in initiating spawning (Hay 1990). Stacey and Hourston (1982) found that mature herring were stimulated to spawn when exposed to filtrates of ripe herring testes. Although whether males or females initiate spawning is unclear, the onset of massive spawning within a school appears to begin once some males have spawned. Both males and females make physical contact with the spawning substrate to test its texture and rigidity (Haegele and Schweigert 1985). A spawning event is usually completed within 1 to 3 days, with larger fish in the stock spawning before smaller fish (Hay 1985), and each event separated by approximately one to several weeks.

Spawning substrate may vary, however Haegele and Schweigert (1985) have observed that herring spawn "almost exclusively on marine vegetation, algae and sea grasses, although frequently eggs adhere to the rocky substrate to which the algae are attached." Emmett et al. (1991) reports that herring spawn primarily on vegetation (e.g., eelgrass [*Zostera* spp.] and algae), structures (e.g., pilings, driftwood), and rocky or rocky-sandy bottoms in the intertidal and subtidal regions. If spawn is deposited on vegetation, Haegele and Schweigert (1985) reports that "they do not appear to favor one vegetation type over another." Others, however, have observed that herring prefer to spawn on coarser vegetation given a choice (Stacey and Hourston 1982; Aneer 1983 in Aneer 1985). Whatever the substrate used, it is generally agreed that spawn is deposited on substrates "free from sediments," as silting may disrupt the spawning sequence (Stacey and Hourston 1982; Lassuy 1989).

Female fecundity is size-specific, with the number of eggs deposited increasing with body size and width. This size-specific fecundity is inversely related to latitude, however, and the number of eggs deposited may range from 4,000 to 134,000 eggs per female (Emmet et al. 1991; Hay 1985). Spawn density and width is a factor dependent on the type of vegetation (i.e., surface area or foliage) and topography (Hay and Kronlund 1987). For example, wide gradual-slope beaches with dense vegetation will likely accommodate higher-density spawn than would steep slopes with narrow bands of vegetation. Generally, density of spawn is highest in lower intertidal to upper subtidal and ranges from single layers to as many as 20 layers (Haegele and Schweigert 1985), although Hourston and Haist (1981 in Hay 1985) found that densities greater than eight or nine layers are uncommon in British Columbia. In very dense spawn, the development and survival of the inner egg masses is poor relative to the outer eggs (Hay 1985). Eggs adhere to vegetation and bottom substrates and generally hatch at night (Alderice and Velsen 1971) within 2 to 3 weeks. The incubation period increases with decreasing temperatures (Emmet et al. 1991).

According to Hourston and Haegele (1980), the larval stage is most vulnerable, with mortalities as high as 99%. Environmental stress during the egg stage can result in malformation or incomplete development of larvae, which can impair survival (ADFG 1985). The onset of feeding in larval herring occurs within approximately 1 week after completion of the yolk-sac stage (Stevenson 1962). Under laboratory conditions, herring larvae have 6 to 8 days at 6ºC and 10ºC after exhaustion of the egg yolk to locate food before starvation (McGurk 1984). Warmer ambient water temperatures during the time that larvae depend on yolk-sac resources may increase larval susceptibility to starvation even further. Copepods, invertebrate eggs, and diatoms comprise the majority diet of early feeding larvae (Hart 1973).

Two to three months after hatching, larvae metamorphose to juvenile form upon reaching about a fork length of 26 mm. At lengths of 25 mm to 40 mm, juveniles begin to school and usually remain in inshore waters during the first summer (Hay 1985). Collaborative studies in Prince William Sound (PWS) (e.g., see Cooney et al. 2001; Paul and Paul 1998; Paul et al. 1998) have shown that young-of-the-year (YOY) juveniles are subject to substantial mortality from starvation during winter periods of plankton diminishment. Because limited winter feeding is insufficient for metabolic demands, YOY juveniles are required to gain sufficient energy stores during summer to successfully overwinter (Foy and Paul 1999). Summer conditions bring a seasonal peak in total zooplankton, and it has been shown that juvenile herring depend on both pelagic and benthic food webs in shallow bays, inlets, and fjords in summer and early fall. Diet studies for juvenile herring in PWS found that barnacle nauplii, large and small copepods, fish eggs, larvaceans, juvenile euphausiids and mysids were the dominant prey items (Norcross et al. 2001). First- and second-year juveniles may school offshore, remaining separated from schooling adults until reaching maturity – generally within 2 to 5 years.

There are migratory and non-migratory subpopulations, or stocks, of Pacific herring. Migratory stocks may migrate offshore to feeding grounds after spawning and return to inshore waters to overwinter in late fall or early winter. Non-migratory resident stocks, such as those found in Lynn Canal, remain in coastal bays and inlets to overwinter and move to adjacent sites to spawn (Carlson 1980; Lassuy 1989).

3.1.2 Lynn Canal Herring Stocks - Distribution and Habitat Use by Life-History Stage

Much of the information below is from Carlson (1980), which provides a comprehensive synthesis of Lynn Canal herring stocks in the vicinity of Auke Bay based on acoustic data, field observations, and sampling data collected from 1973 to 1975 (Figure 2). Therefore, Carlson represents a retrospective summary of information related to the stock when it was considered relatively "healthy."

Summer Feeding: Tagging studies have shown that Auke Bay stocks do not intermingle with other stocks in summer feeding areas (Dahlgren 1936 in Carlson 1980; Carlson 1977). From late May through September, scattered schools of adult herring were found over much of the nearshore waters of southern Lynn Canal and northern Stephens Passage, with consistent concentrations along the western shore of Douglas Island (Carlson 1980). Depth distribution ranged from the surface to near-bottom, but mostly averaged between 5 m to 37 m. After mid-July, schools concentrated at 10- to 37-m depths. Copepods were the primary food of Auke Bay herring during the summer, and were primarily composed of larger species that concentrate near the bottom (Haight 1973 in Carlson 1980).

Fall migration: Adult herring generally moved deeper in the fall (October) as water and air temperatures cooled. Carlson (1980) suggests that the breakup of the thermocline serves as a cue that stimulates movement of Pacific herring from feeding grounds to wintering areas. Herring movements, from open passages into more sheltered wintering areas in Auke Bay and Fritz Cove, were frequently tracked by larger predators such as humpback whales, Steller sea lions, and sea birds.

Overwintering: Once on the wintering grounds of Auke Bay and Fritz Cove, herring generally ceased feeding (Carlson 1980). Herring schools concentrated at 52 m to 85 m, close to their yearly maximum depths. During daylight hours, adult herring remained deep and close to the bottom, and were generally not distinguishable on an echo sounder; at night, they dispersed and rose in the water column. It is generally thought that in the winter, herring are avoiding light levels sufficient for visual detection by predators, and that they use the bottom for cover and protection. Carlson's surveys throughout the entire length of Lynn Canal suggested that the stock of herring that overwintered in Auke Bay and Fritz Cove comprised the major stock of fish that spawned in Auke Bay and Lynn Canal.

More recent work involving acoustic surveys validated by midwater trawl suggests that mature Lynn Canal herring overwinter in low current areas near the shoreline from mid-Douglas Island to the backside of Benjamin Island (personal communication, Mike Sigler NMFS 2004).

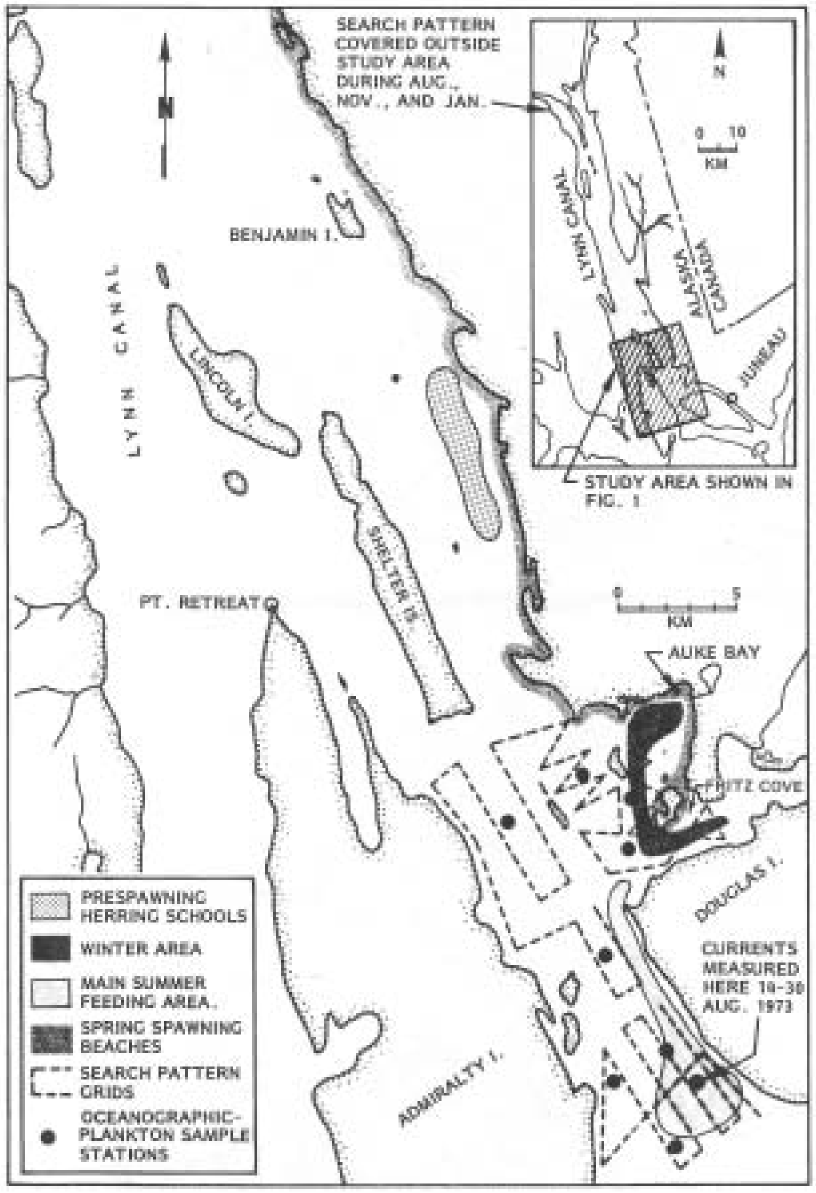

Figure 2. 1973 to 1975 seasonal distributions of herring schools in the vicinity of Auke Bay, Lynn Canal, Alaska, showing main concentrations, standard monthly search patterns, waters surveyed up the length of Lynn Canal, oceanographic and plankton sample stations, and stations where currents were measured. (Source: Carlson 1980)

<u>Prespawning aggregations and spawning locations</u>: From February to early March (when days neared 10 hours) herring moved from wintering grounds in Fritz Cove and Auke Bay to concentrate near the bottom off their traditional spawning beaches in Lynn Canal (Figure 2) (Carlson 1980). Herring remained there at depths of 73 m to 110 m until late April or early May, when sea-surface temperatures increased to 5ºC to 6ºC and plankton blooms generally obscured surface visibility. Herring then moved into tidal shallows and commenced spawning, typically over a 2- to 3-week period between late April and early May (from 1973 to 1978), although spawning did extend into late May in some years. No feeding occurs before and during spawning; active feeding occurs thereafter. After spawning, herring returned to summer feeding areas.

In more recent years, some isolated instances of spawning have been observed in Auke Bay as late as June or July (personal communication, Bruce Wing, NMFS). The Lynn Canal survey area also includes Oliver's Inlet on the northeast of Admiralty Island, and Taku Inlet, south of Juneau (personal communication, Dave Harris, ADF&G). Maps of annual shoreline spawning locations since 1972 are described and shown in the next section (3.1.3); it is unclear if the location of pre-spawning aggregations have changed since first described.

Larval and juvenile rearing: Little specific information exists on the larval and juvenile distribution of herring in Lynn Canal, although Haldorson et al. (1990) noted the seasonal abundance of larval herring in Auke Bay is coincident with spring peaks in copepod abundance. It is generally thought that after hatching, herring larvae are locally retained in nearshore waters close to their natal spawning grounds, where they feed and grow in the protective cover of shallow water habitats. Larval metamorphosis occurs in late July through early September, with schools of juvenile herring observed in the head of Auke Bay in late August (Jones 1978 in Ziemann and Fulton-Bennett 1990). Juvenile herring 1 to 2 years of age are thought to be more dispersed in surface schools throughout Lynn Canal than are adult populations (personal communication, Mike Sigler, NMFS).

3.1.3 Lynn Canal Herring Stock Status and Trends

Stock definition. Stocks of Pacific herring vary greatly in size and productivity throughout southeast Alaska, and have been defined historically by a number of means. The term “stock” is used by the Alaska Department of Fish and Game (ADF&G) to refer to groups of Pacific herring harvested in a particular area, whether these fish are genetically related or not. In a status review of Pacific herring in Puget Sound, a study by Stout et al. (2001) concludes that little evidence exists of significant genetic differentiation between herring populations within the eastern North Pacific Ocean (i.e., Puget Sound, southeast Alaska, California, Oregon, and British Columbia). Although the problem of stock identification has not been resolved for Pacific herring, each spawning area that supports a commercial fishery is managed as if it contained a genetically distinct stock (Trumble and Humphreys 1985).

Stocks near Sitka, Craig, and Auke Bay were first differentiated in the 1930s using spawning and feeding locales, vertebral counts, growth rates, and tagging studies (Rounsefell and Dahlgren 1935 in Carlson 1980). By the 1970s, five major stocks or populations were identifiable by their concentration on wintering grounds: 1) Sitka, 2) Auke Bay, 3) Craig-Hydaburg, 4) Deer Island – Etolin Island (near Wrangell), and 5) Ketchikan. Biomass estimates in each locale consistently exceeded 2.27 million kg (i.e., approximately 2500 tons, the minimum level to be classified as a major stock) in each locale during the winters of 1971 to 1979 (Carlson 1980).

At least 14 major herring stocks, differentiated by spawning area, are currently managed for commercial harvest in southeast Alaska under minimum spawning threshold levels (Hebert and Pritchett 2002). Stocks with a spawning biomass of less than 2000 tons are not considered for harvesting in either the southeast Alaska winter bait or sac roe fisheries. In general, the stocks that spawn on the outer coastal areas are more productive than stocks that spawn in inside waters (Hebert and Pritchett 2002).

Herring that winter in Auke Bay and Fritz Cove apparently constitute most of the stock of fish that spawn in Lynn Canal (Carlson 1980). The Lynn Canal stock is one of the least migratory stocks in southeast Alaska (personal communication, Kevin Monagle ADF&G). Tagging studies have shown that the Lynn Canal (Auke Bay) stock has a distinct summer feeding area and does not intermingle with other stocks, unlike the outer coast Sitka and Craig stocks, which migrate and intermingle in summer feeding areas (Carlson 1980).

Stock management. The ADF&G manages herring stocks using minimum spawning biomass thresholds and a variable harvest rate policy (Carlile 2003). The original goal of the department's threshold/variable harvest rate policy was to maintain herring populations above previously established threshold escapement levels. These levels and the variable harvest rate schedule are intended to protect herring stocks from sharp reductions due to recruitment failure, to maintain adequate abundance of herring as prey for commercially important predator species such as salmon, and to provide for the highest quality commercial herring products.

The department establishes biomass thresholds for each fishing area, and the abundance of mature herring for each stock is assessed before harvest is allowed to occur (details below). Harvest of herring is generally allowed at an exploitation rate of between 10% and 20% above the minimum threshold level. If the spawning biomass at an area is forecast to be below its threshold, no harvest is allowed. When the spawning biomass forecast for an area equals the threshold, the department exploitation rate is 10% of the estimated spawning biomass. For each incremental increase in the spawning biomass equal to the threshold, the exploitation rate increases by 2%. The maximum 20% exploitation rate is achieved when the spawning biomass is 6 times the threshold level (Carlile 2003).

The herring spawning threshold level for the Lynn Canal fishery is currently 5000 tons (10 million pounds). This threshold value was increased from 4000 tons in 1983 based upon a reevaluation of historical herring spawning population levels and the failure of the Lynn Canal stock to increase in size under the previous threshold level. The Lynn Canal herring biomass threshold was originally set based on acoustic estimates (from 1971-1972 through 1981-1982 seasons), linear miles of shore receiving spawn (20 years from 1953 through 1982), and dive surveys (1978, 1980, 1983).

Stock assessment. Area-specific biomass thresholds were initially established based on a variety of factors, including historical estimates of abundance (determined from hydroacoustic surveys of adult biomass, linear miles of spawn, and diver surveys of egg biomass); historical and personal knowledge; judgment of research and area management biologists; personal contacts with fishers and other public regarding the relative size and area of various stocks; and biologist's judgment regarding minimum quotas that could be managed and controlled (Carlile 2003). The thresholds were established with the expressed recognition that the levels would be subject to change as new data and research became available. Since the original establishment of the thresholds, up to an additional 17 years of spawning biomass, harvest, fecundity, and growth data have been collected, analyzed, and evaluated for many Southeast Alaska herring populations. Biomass estimates have been improved with the implementation and refinement of diver surveys to estimate total egg deposition. In addition to the availability of more data, recent research on threshold management strategies provides new guidelines for setting harvest thresholds based on an improved understanding of fish-population dynamics (Stocker et al. 1985; Trumble and Humphreys 1985).

Historically, two direct observation methods have been used for estimating biomass of herring stocks in southeast Alaska: 1) post-spawning egg deposition dive surveys, and 2) vessel hydroacoustic surveys (Hebert and Pritchett 2002). However, beginning in 1994, ADF&G modified the primary method of forecasting herring abundance for major spawning stocks to age structure analysis (ASA), which relies on time series of herring population structure data collected in the field. ASA is currently used to forecast herring biomass for those stocks with adequate historical data (e.g., Revillagigedo Channel, Sitka, Craig, Tenakee Inlet, and Seymour Canal).

The biomass of mature herring in Lynn Canal is currently derived solely from spring surveys of spawn deposition along shorelines. Biomass estimates are based on a general relationship of 250 tons of adult herring per mile of spawn observed (unpublished data ADF&G), a relatively low rate compared with that of other stocks. This lower rate is because spawning generally occurs in a narrow band in the intertidal and shallow subtidal zone; in comparison, Sitka stocks spawn at an average depth of 10 m to 12 m and may spawn down to a maximum depth of 24 m (personal communication, Marc Pritchett, ADF&G).

Stock status and trends. Before 1980, the adult spawning biomass of Lynn Canal herring stocks was consistently above 4000 tons and supported several commercial fisheries, including a sac roe fishery, bait pound fishery, and a winter food and bait fishery (Figure 3). This stock declined in 1982 and has since remained at low levels. Current estimates by ADF&G suggest that the population of mature adult fish has fallen to near 1000 tons. The 1000-ton estimate has been corroborated by hydroacoustic surveys of over-wintering populations of adult herring in the Juneau area (personal communication, Mike Sigler, NMFS).

The linear extent (miles) of Lynn Canal shoreline with documented herring spawn (a factor used to estimate adult biomass) has similarly declined since the 1970s (Figure 3). The documented spawn for the Lynn Canal herring stock from 1953 to 1981 ranged from 6 to 28 nautical miles, and averaged approximately 12 miles. Since 1982, the documented spawn has ranged from 0.5 to 7 nautical miles, averaging less than 4 nautical miles. In the spring of 2003, only 3 miles of herring spawn were observed in all of Lynn Canal.

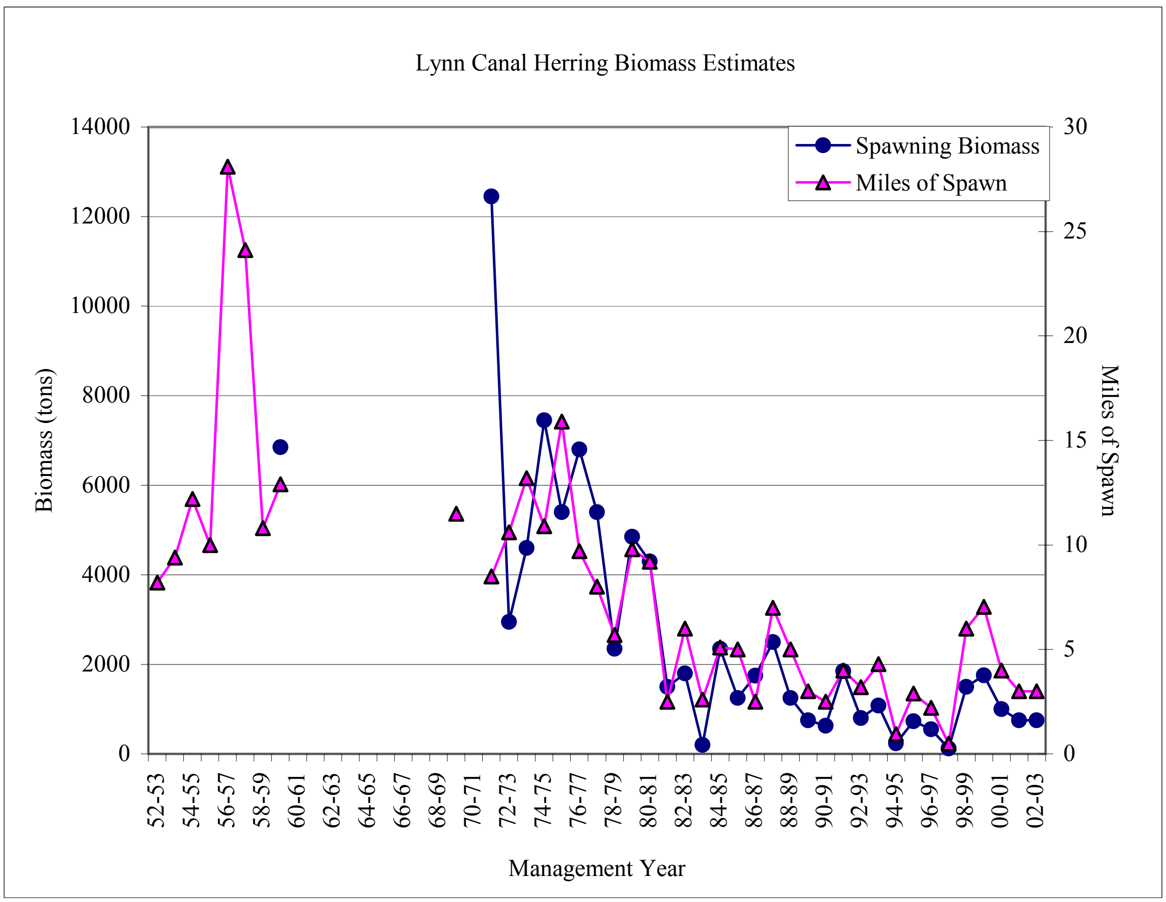

Figure 3. Adult biomass and miles of spawn for Lynn Canal Pacific herring stocks (ADF&G unpublished data, 2004).

Spawning location in Lynn Canal has also changed considerably since historic times (Figure 4). Lynn Canal herring traditionally spawned from Auke Bay to Point Sherman, including Berners Bay. In recent years, however, spawning activity for the entire Lynn Canal herring stock is now centered between Point Bridget and the Berners Bay flats, with limited spawning within Auke Bay.

Total annual Lynn Canal herring harvest averaged less than 1000 tons from 1959 to 1981-1982, before fishing was stopped in 1982-1983 (Figure 5). Up through the early 1970s, much of the harvest was taken by pound net at Indian Cove to provide bait for the commercial long-line, pot, and recreational fisheries. Purse seine and gillnet fisheries targeting herring for sac roe then surpassed the bait fishery in the 1972-1973 season, and continued to harvest the bulk of adult herring until the fishery was closed in 1982-1983, when biomass fell below the 4000-ton spawning threshold. As previously noted, the herring-spawning threshold level for the Lynn Canal fishery was increased to 5000 tons in 1983 based on the failure of the Lynn Canal stock to increase in size under the previous level. Why harvest occurred in the 1972-1973 and 1981-1982 seasons when spawning biomass thresholds were not met is unclear from the records.

Substantial interannual variability in harvestable biomass appears to be a commonality of most herring stocks in southeast Alaska (Figure 6). For instance, sac roe harvest of Revillagigedo Channel herring stocks was nonexistent before 1975, peaked near 3000 tons in 1983, and finally declined again below harvestable levels in 1999. In Sitka Sound, current harvests are near 10,000 tons, a vast increase over early 1970s harvest levels (<1000 tons) that were once comparable with those seen on Lynn Canal stocks.

Hypotheses Concerning Decline. Various hypotheses have been put forward as to why Lynn Canal herring stocks have declined, although none have been substantiated through careful scientific analysis. These hypotheses include one or some combination of the following factors: overfishing, increased predator populations, disease, habitat alteration or degradation (especially in Auke Bay), water pollution, and unfavorable oceanographic conditions. Little directed research has been conducted by ADF&G to investigate reasons for the Lynn Canal stock decline, because current effort concentrates on managing commercially viable fisheries. However, ADF&G has continued to conduct spawn deposition surveys and collect age-structure, weight / condition, and fecundity information for the Lynn Canal stock. A detailed, retrospective analysis of these data will yield clues that narrow the range of possible factors.

In a quantitative assessment of the frequency with which explanations have been attributed to herring stock collapses worldwide, Pearson et al. (1999) found that overfishing (74% of the cases) was the most frequently cited cause, followed by environmental change (50% of cases), changes in food supply (15%), predation (2%), disease (2%), and habitat modification (2%). In most cases, these factors were seen to have acted in combination with others; single-factor causes other than overfishing (37%) or environmental change (13%) alone were rare.

Overfishing may have played a role in the initial decline of Lynn Canal herring stocks. As previously noted, stocks were harvested at a fairly low rate (<1000 tons) until stock declines led to a fishery closure in 1982. Harvest did occur in some seasons when minimum spawning biomass thresholds were not met, and the Lynn Canal stock may have been especially susceptible to brief periods of overfishing due to poorly understood factors, such as its limited migratory range.

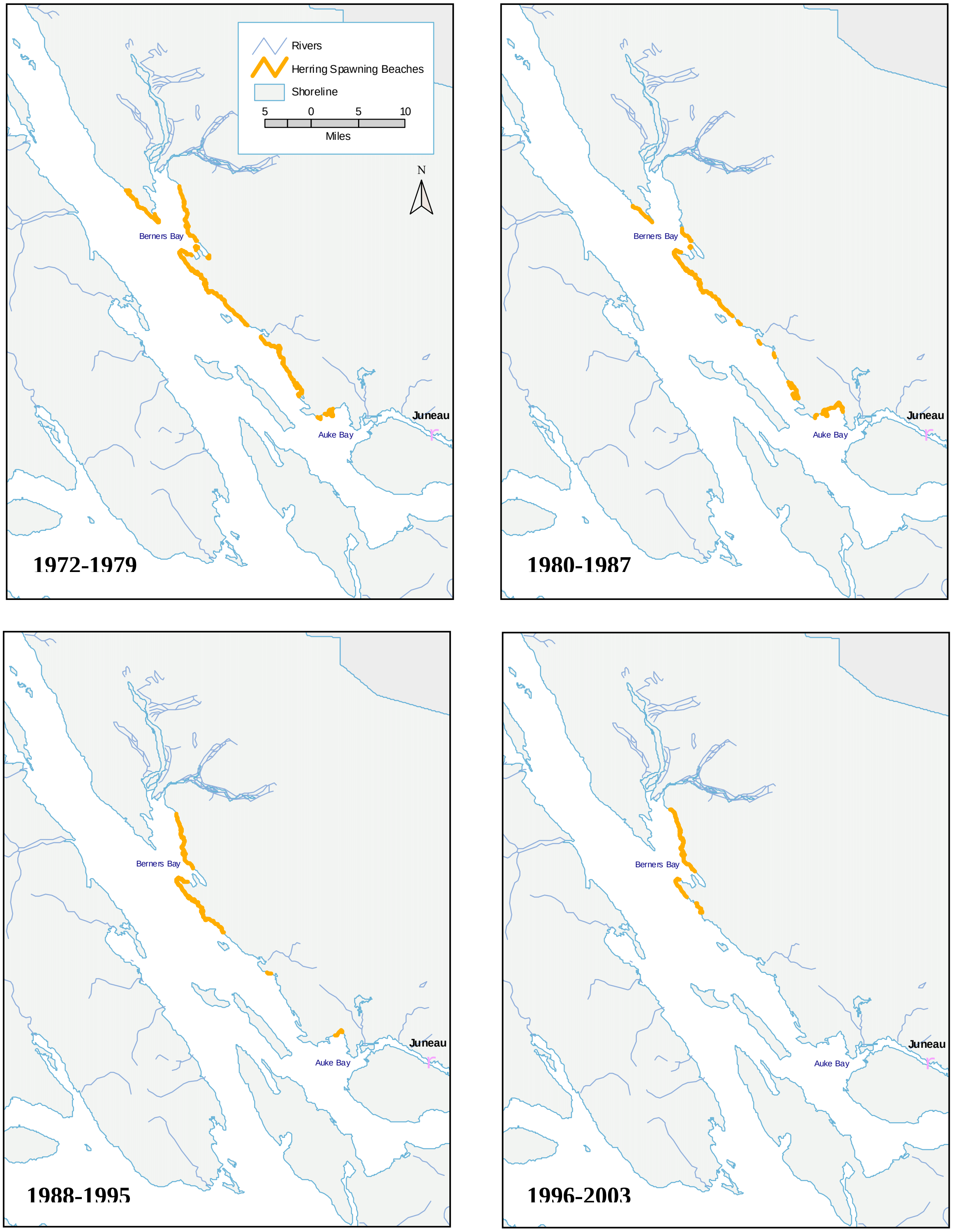

Figure 4. Documented spawning locations (in orange) for Lynn Canal Pacific herring stocks over cumulative 8-year intervals: 1972-1979, 1980-1987, 1988-1995, 1996-2003 (ADF&G unpublished data, 2004).

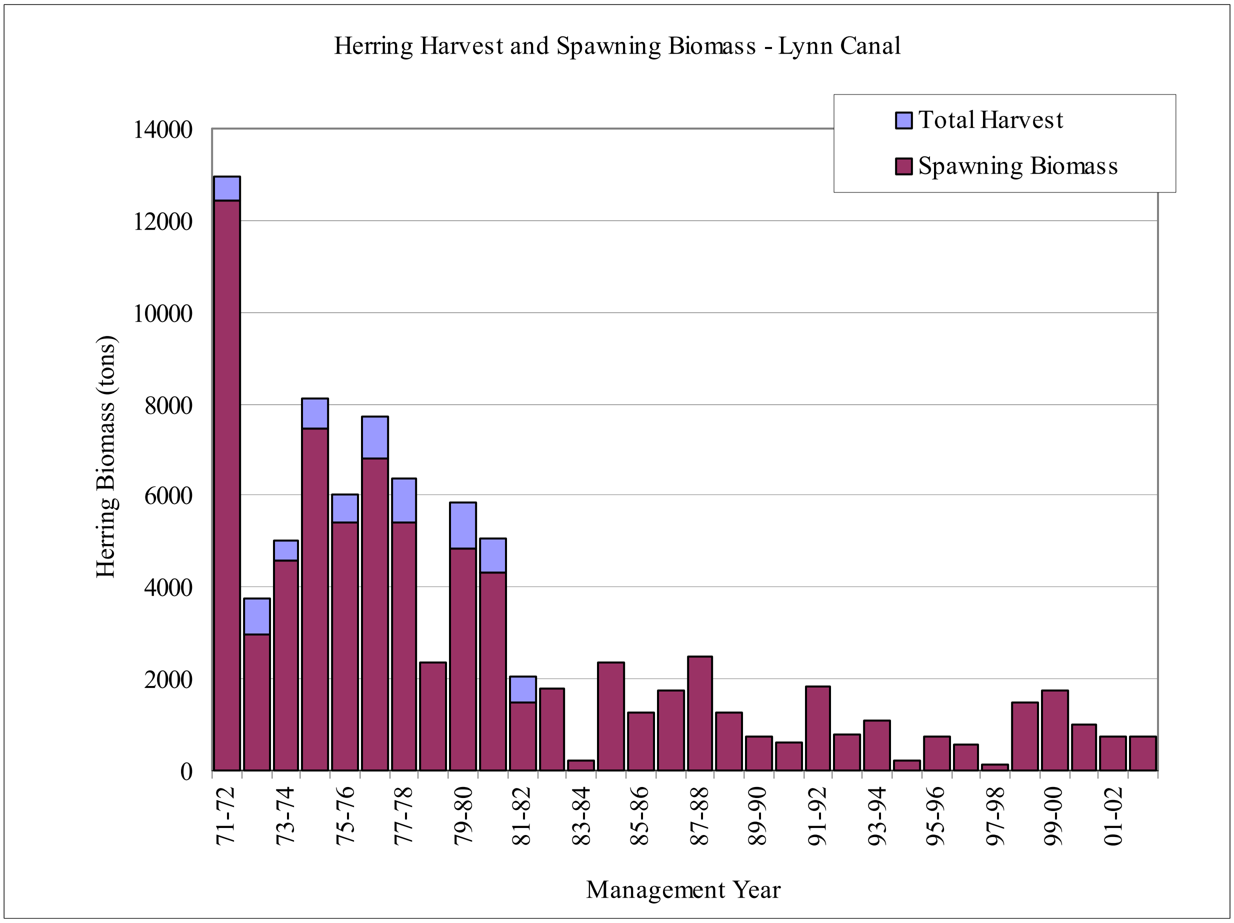

Figure 5. Lynn Canal herring harvest and spawning biomass from 1971 to 2003 (ADF&G unpublished data 2004).

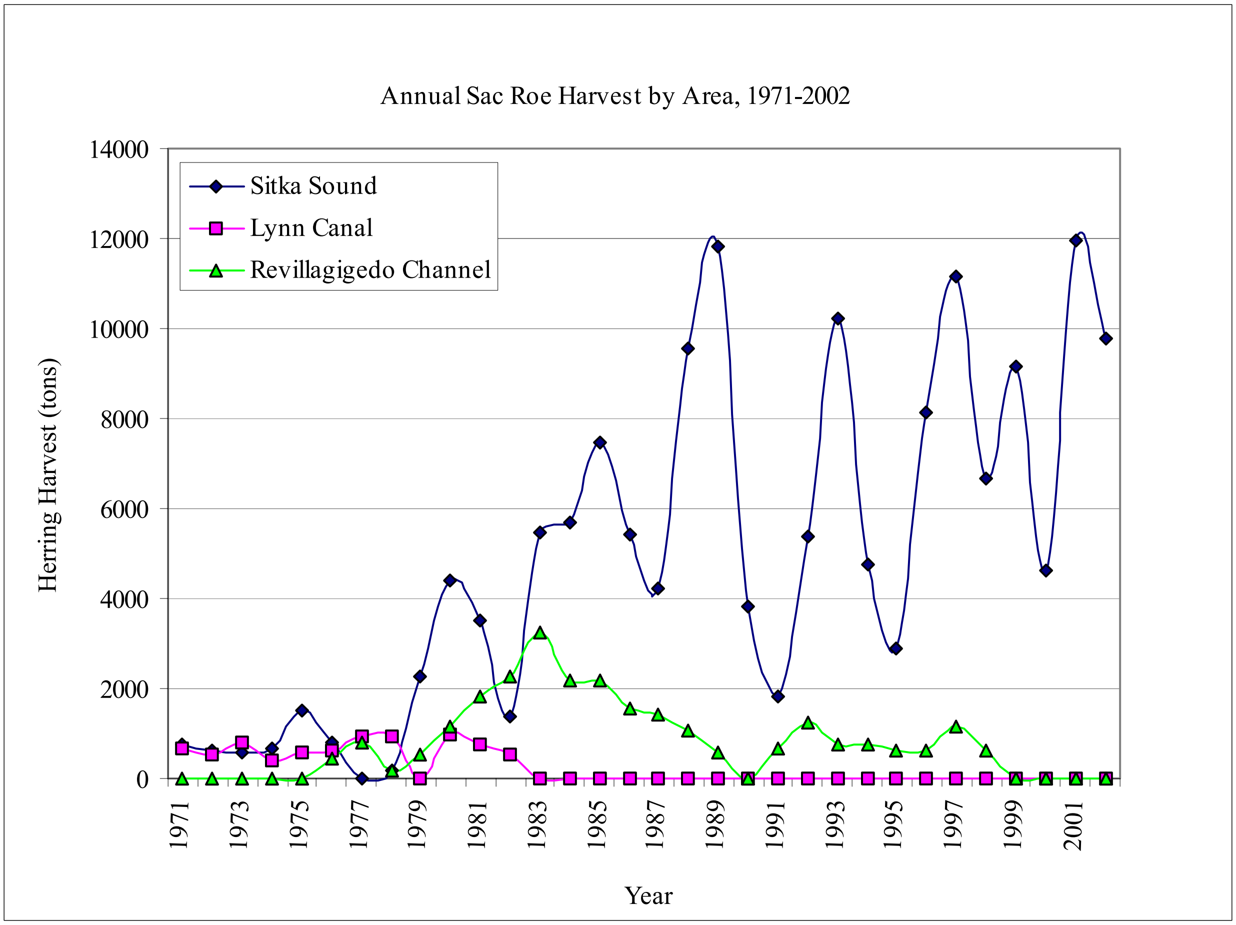

Figure 6. Annual southeast Alaska sac roe herring harvest by area, in tons, 1971-2002 (data from Table 5, Hebert and Pritchett 2002).

However, if long-term declines were the result of overfishing alone, recovery would have been expected during the 20-year period since commercial exploitation has ceased. This recovery cycle has been documented elsewhere. For example, a significant decline in Sitka stocks prompted a fishery closure in 1977; however, stocks soon rebounded allowing a harvest of 2.25 tons by 1979 (O'Claire and O'Claire 1998) (see Figure 6). In British Columbia, eight of the nine major Pacific herring stocks in British Columbia underwent a drastic crash in the mid-1960s that was caused by a combination of intense harvests and unfavorable ocean conditions that resulted in poor recruitment (Hourston 1980 in Lassuy 1989). However, most stocks rebuilt in the 1970s as environmental conditions improved and fishing closures took effect.

Predation pressure by marine mammals may also be sustaining the low biomass of Lynn Canal herring stocks. Resident populations of Steller sea lions (*Eumetopias jubatus*) use haulouts throughout Lynn Canal and are known to feed on herring. (personal communication, M. Sigler NMFS). A 3-year study currently being conducted by the National Marine Fisheries Auke Bay Laboratory to assess the seasonal prey field of Steller sea lions near two haul-out areas - Lynn Canal and Frederick Sound - (Sigler 2004) may provide information on the degree to which sea lions forage on these herring stocks. Recent increases in harbor seal (*Phoca vitulina*) populations have also been implicated in the declines of some local herring stocks in British Columbia (personal communication, D. Hay, DFO Canada). Natural mortality has been depensatory, or inversely related to biomass, in Strait of Georgia herring stocks

(Stocker et al. 1985). The principle mechanism suggested for depensation is increased natural mortality as a result of predation associated with smaller herring school sizes at low biomass (Clark 1974 in Stocker et al. 1985).

Disease and changing climate may also be considered as possible factors in the decline, or limited recovery, of Lynn Canal herring stocks. Mass herring mortalities observed in Auke Bay in 1989 were a result of viral erythrocytic necrosis (VEN), an infection that causes severe anemia in herring and makes them extremely susceptible to environmental stress (unpublished memo, Ted Myers ADF&G). The current level of infection rates in Lynn Canal stocks is unclear. Regime shifts in the Northern Gulf of Alaska in 1977 also coincided with the period when Lynn Canal herring stocks began their declines. These changes have apparently been manifested as warmer sea-surface temperatures and lower salinities (associated with wetter conditions) in Auke Bay (Wing and Pella 1998) as compared with those of outer coastal waters. No directed study has addressed this hypothesis, however.

Another factor cited by regional experts has been the progressive deterioration of shoreline habitat in Auke Bay (personal communication, Sue Walker NMFS and Dave Harris ADFG; O'Claire and O'Claire1998), which once was a major spawning area for the Lynn Canal stock . Auke Bay has been increasingly subjected to the cumulative effects of shoreline development and human use since the 1980s. These impacts include construction of a floating breakwater, docks and marinas for commercial and recreational vessels, fueling depots, sewage and waste treatment discharges, and ferry terminal expansion. In addition, current proposals include development of a seafood processing plant. The historic extent of eelgrass (*Zostera marina*) beds once used by herring as spawning habitat have also declined in the bay over time (personal communication, Sue Walker, NMFS). Though direct evidence for linking the combined impacts of pollution, habitat loss, and other coastal human stresses to declines of the Lynn Canal spawning stock is, in part, circumstantial, similar declines have been noted elsewhere, particularly near coves, inlets, and estuaries, where development has occurred. For example, the loss of historically important herring spawning habitat has been documented in Nanaimo, Pender, and Ladysmith Harbors, British Columbia (DFO Canada 2004 website), as well as in Eagle Harbor, Puget Sound (Chapman et al. 1941). Relative to other areas where herring spawning continues (e.g. Berners Bay), these bays have been substantially altered by human settlement, industrial development, log storage, and marine transport.

Scrutiny of Pacific herring stock population trends in other regions provides some additional guidance on the factors affecting this historically overfished and naturally variable resource. For example, San Francisco Bay herring showed an increasing trend in population size from 1974 to 1982, primarily because of improved spawn survey coverage and methods (Trumble and Humphreys 1985). Overall populations of Pacific herring in Puget Sound appear to be relatively healthy, although specific stocks, such as those centered around Cherry Point and Discovery Bay, are considered "depressed" or "critical" based on decreasing trends in overall spawning biomass (West 1997; Stout et al. 2001). British Columbia stocks in the early 1980s appeared to be in average to good condition and stable (Trumble and Humphreys 1985); however, with the exception of the Strait of Georgia herring stock which is now near peak levels, most British Columbia stocks have declined since the mid to late 1980s and now sustain only modest fisheries (DFO 2002). In the Gulf of Alaska, larger stocks have fluctuated in abundance since the start of the roe fishery, although smaller stocks have been highly variable, and some showed declines (Trumble and Humphreys 1985). The PWS herring fisheries collapsed in 1993 after record biomass levels and harvests; currently, biomass remains below historic averages, and commercial harvest has been closed since the 1999-2000 season (Pearson et al. 1999). Mortality from Viral Hemorrhagic Septicemia Virus (VHSV) is now seen as one of the factors causing the PWS herring collapse in 1993 and the setback in 1999 (Marty et al. 2003).

3.1.4 Summary Habitat Requirements

A conceptual model (Figure 7) summarizes patterns of Pacific herring habitat distribution and use by life-history stage, and provides the foundation for subsequent analyses of exposure pathways and ecological effects.

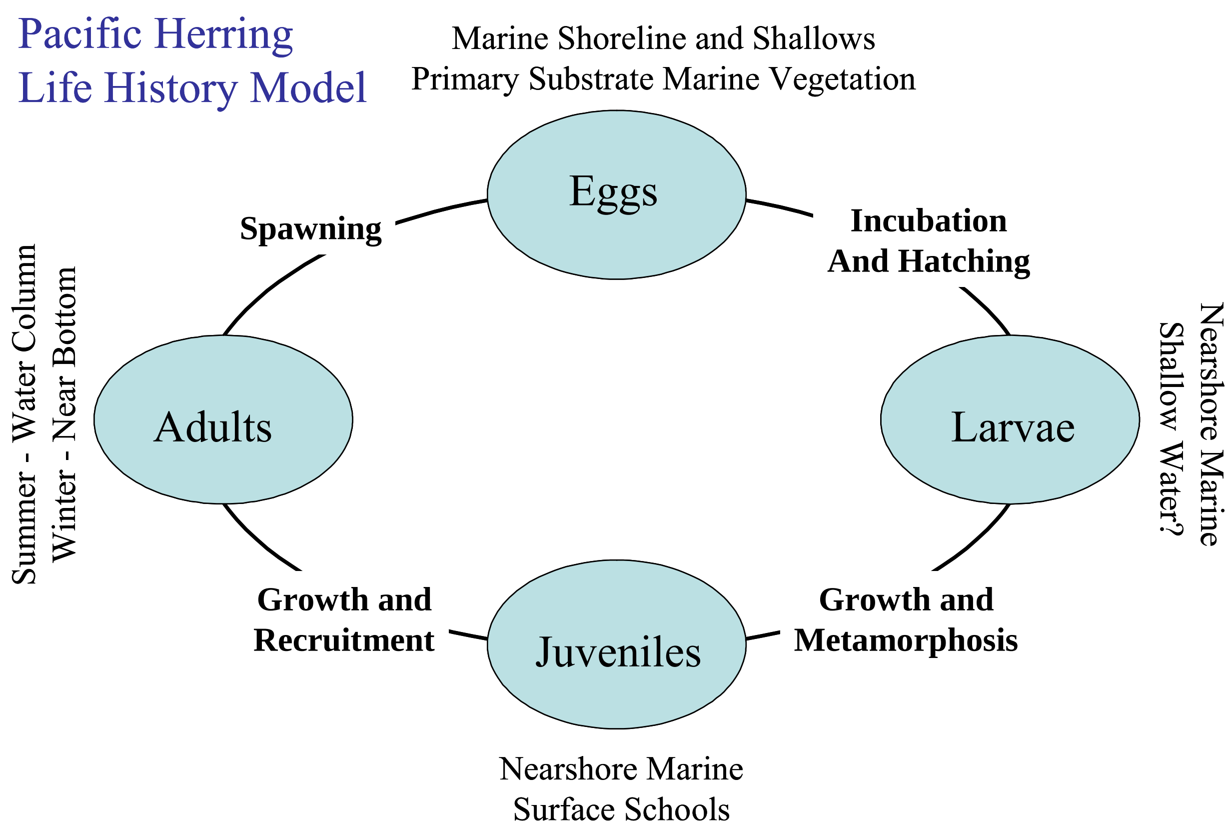

Figure 7. Summary habitat requirements and processes associated with major life-history stages of Pacific herring.

3.2 Eulachon

3.2.1 General Life History and Ecology

Eulachon, *Thaleichthys pacificus*, the largest of the North American Pacific Coast smelts, are anadromous fish that occur from northern California to the southern Bering Sea. Within their range, eulachon spawn regularly in only 30 to 40 major rivers (DFO 1999). In Southeast Alaska, spawning begins as early as April when eulachon gather in large schools off the mouths of their spawning rivers. Hay and McCarter (2000) suggests that if eulachon home to natal rivers, imprinting during egg and early larval stages in freshwater is improbable because of the shortness of these stages and the lack of necessary physiological tissue. Therefore, imprinting is more likely specific only to estuarine waters rather than to specific rivers, either within estuaries (e.g., Berners Bay) or to tributaries in large river systems (e.g., Fraser River). Adults aggregate near the bottom of estuarine and riverine channels during their spawning migration. Spawning occurs in the lower reaches of rivers with moderate velocities at ambient temperatures of 3ºC to 10ºC (DFO 1999). Upstream migration is closely linked to the spawning river water temperature.

Temperatures below 4ºC may retard adult migrations (Emmett et al. 1991). Eulachon mass spawn at night without building nests. Female fecundity is size-specific, and the number of eggs laid ranges from approximately 7,000 to 31,000 per female (Emmet et al. 1991). Adults usually spawn at 3 years of age at a length of 14.0 cm to 20.0 cm. Eggs are typically deposited on pea-size gravel or in sandy areas with debris. When the eggs are fertilized externally, the outer membrane ruptures and turns inside out and remains attached to the inner membrane at one spot. The outer membrane is adhesive and attaches to the substrate. Eggs hatch within 3 to 5 weeks. As with the Pacific herring, the incubation period increases with decreasing temperature (Emmet et al. 1991). Eulachon are gonochoristic (bisexual) and iteroparous (repeat reproductive cycle); however, most eulachon die after spawning (Emmet et al. 1991; ADFG 1994).

Newly hatched larvae are 4 mm to 7 mm. River currents quickly flush the larvae to marine waters where they may be retained in low-salinity, estuarine surface waters for several weeks or more (Hay and McCarter 2000). Although this environment may provide protection from most stenohaline marine fish and invertebrates, it may make small spawning runs more sensitive to ocean climate changes, in particular those that affect freshwater discharge (Hay and McCarter 2000). Both dispersion and retention mechanisms appear to affect larval distribution (Hay and McCarter 2000). Surveys conducted in British Columbia show that larvae disperse from relatively small spawning areas to an area of 10 km^2 to 1000 km^2, but appear to be retained in inlets, with often higher densities observed on the seaward side of inlets, suggesting a retention effect (Corialis effect). Larvae are planktivorous and feed primarily on phytoplankton, copepods, ostracods, cladocerans, mysids, and larvae of various species, including their own (Emmet et al. 1991). Metamorphosis to the juvenile stage occurs at lengths of about 30 mm to 35mm.

The distribution and ecology of juvenile and pre-spawning adult eulachon is not well known. Juveniles appear to live in near-benthic habitats in depths of approximately 20 m to 150 m during their first 2 to 3 years (Hay and McCarter 2000). Adults are found in the marine neritic zone at various depths until the sexually mature segregate from the rest of the population to migrate to spawning rivers. Juveniles and adults feed primarily on euphausiids, copepods, and other planktonic crustaceans (Emmet et al. 1991).

3.2.2 Lynn Canal Eulachon Runs - Habitat Use by Life-History Stage

Although specific information on the marine stages of eulachon life history is sparse, several recent studies provide useful guidance on the timing of freshwater habitat use by adult eulachon in Berners Bay Rivers.

Research conducted in 1995 to 1997 in Berners Bay documented that eulachon spawning runs began in early May and generally lasted from 10 to 12 days, with some late spawning continuing through the end of May (Marston et al. 2002). Separate research on the Antler River in 2002 documented adult eulachon abundance peaking in late April to early May (K. Koski, NMFS unpublished progress report). Fish were found in the river from April 19 to May 21, although most fish remained in fresh water for only a short time (1 to 3 days). Radio telemetry data showed that the maximum migration up the Antler River was approximately 4 km, with most observations clustered in the lower 2 km of the river. Eulachon collected in the Antler River study ranged from age 1 to age 6. However, both male and female eulachon were represented predominantly by age-3 (>50%) and age-2 (>25%) individuals.

Studies on the Chilkat River documented that eulachon migrated, spawned, and died within the lower 12 km of the river (Bishop et al. 1989 in Betts 1994). They suggested that spawning occurred in deep channels, off points of land in spawning substrates of coarse sand or pea gravel. Ocean tides influence the Chilkat River up to the 4-mile point, and eulachon generally entered the river channels in a seasonal high tide after milling at the mouth. Eulachon were generally found in greatest concentration in the lower 6 km of the river during high tides (Betts 1994).

The timing, movements, and biomass of eulachon pre-spawning aggregations in Berners Bay were documented by Sigler et al. (in review) using acoustic surveys, in combination with observations by remotely operated vehicle (ROV), gillnet catches, and midwater trawl surveys. In both 2002 and 2003, eulachon abundance increased during early April, peaked in mid-April, and then decreased later in the month. However, interannual eulachon biomass estimates were highly variable, declining from approximately 2034 metric tons in 2002 to only 76 tons in 2003. Pre-spawning aggregations appeared to form in the Bay itself, moving from the outer part of the Bay (Point Saint Mary) toward the Berners River system. These schools were found at depths ranging from 30 m to 130 m and appeared to be composed exclusively of eulachon

Little specific information exists on the larval and juvenile distribution and abundance of eulachon in Lynn Canal, although Haldorson et al. (1990) noted the seasonal abundance of larval eulachon in Auke Bay coincident with spring peaks in copepod abundance. Eulachon were the most abundant larval fish collected in Auke Bay by oblique Tucker trawls (0.505-mm mesh) from mid-March to mid-June during 1986 and 1987.

3.2.3 Status and Trends of Eulachon Runs in Lynn Canal

Population/Stock definition. Eulachon are primarily harvested for subsistence or personal use in the Lynn Canal region. Because much of this harvest is sustainable, there has been little need for intensive management of the fishery. More recently, however, a number of factors (proposed development projects, perceived population declines, and listing of Steller sea lions as threatened under the Endangered Species Act) have led to some efforts at establishing some baseline index streams for population monitoring. Below we summarize the available information on the location, harvest, management, trends, and ongoing research on Lynn Canal eulachon populations.

Runs of eulachon are found in a number of freshwater drainages in the Lynn Canal (Table 2; Figure 8), and up to 33 spawning runs have been documented for southeast Alaska (Sigler et al. in press). Of these, the importance of the Chilkat and Chilkoot Rivers to subsistence harvest (customary and traditional use) has been well-documented (Betts 1994; personal communication, M. Turek, ADF&G). Eulachon are harvested in the intertidal waters at the river mouths during the late winter to early spring when the runs are strong and the fish appear in large numbers. In practice, this fishery is regulated by local rules developed by traditional harvesters rather than by external state or federal regulations (Betts 1994). Traditional use of runs in Berners Bay is also thought to have occurred, but is less well-documented and currently is in the State of Alaska's Juneau nonsubsistence area (personal communication, M. Turek, ADF&G). Eulachon may be taken in Berners Bay at any time under personal-use fishing regulations, and there are no bag or possession limits.

Table 2. Documented Freshwater Systems with Eulachon Runs in North Lynn Canal

Freshwater system	GeographicVicinity	Sources	Comments
Chilkat River	Haines	Koski 2002, Betts 1994, R. Bachman ADF&G, M. Sigler NMFS MESA[1], ADF&G	Large run, important subsistence source, documented as ecologically important food source for birds and marine mammals
Chilkoot River	Haines	Betts 1994, R. Bachman ADF&G	Smaller, sporadic run (5%-10% of Chilkat), important subsistence source
Skagway River	Skagway	R. Bachman ADF&G	Smaller, sporadic run; large returns in 2003
Endicott River	West Lynn Canal	R. Bachman ADF&G	Large run
Katzehin River	Chilkoot Inlet	R. Bachman ADF&G	Small run
Taiya River	Skagway	Betts 1994, R. Bachman ADF&G	Small run
Eagle River	South of Berners Bay	Betts 1994	Small run
Ferebee River	Taiyasanka Harbor	R. Bachman ADF&G	Small run
Antler River	Berners Bay	Koski 2002, Marston et al. 2002, Sigler et al. in press	Documented by sources as ecologically important food source for birds and marine mammals
Berners River	Berners Bay	Koski 2002, Marston et al. 2002, Sigler et al. in press	Documented by sources as ecologically important food source for birds and marine mammals
Lace River	Berners Bay	Koski 2002, Marston et al. 2002, Sigler et al. in press	Documented by sources as ecologically important food source for birds and marine mammals
Mendenhall River	Juneau	MESA[1], ADF&G, Koski 2002	
Taku River	Taku Inlet	MESA[1], ADF&G	
Excursion River	North Icy Strait	MESA[1], ADF&G	

[1] most environmentally sensitive areas

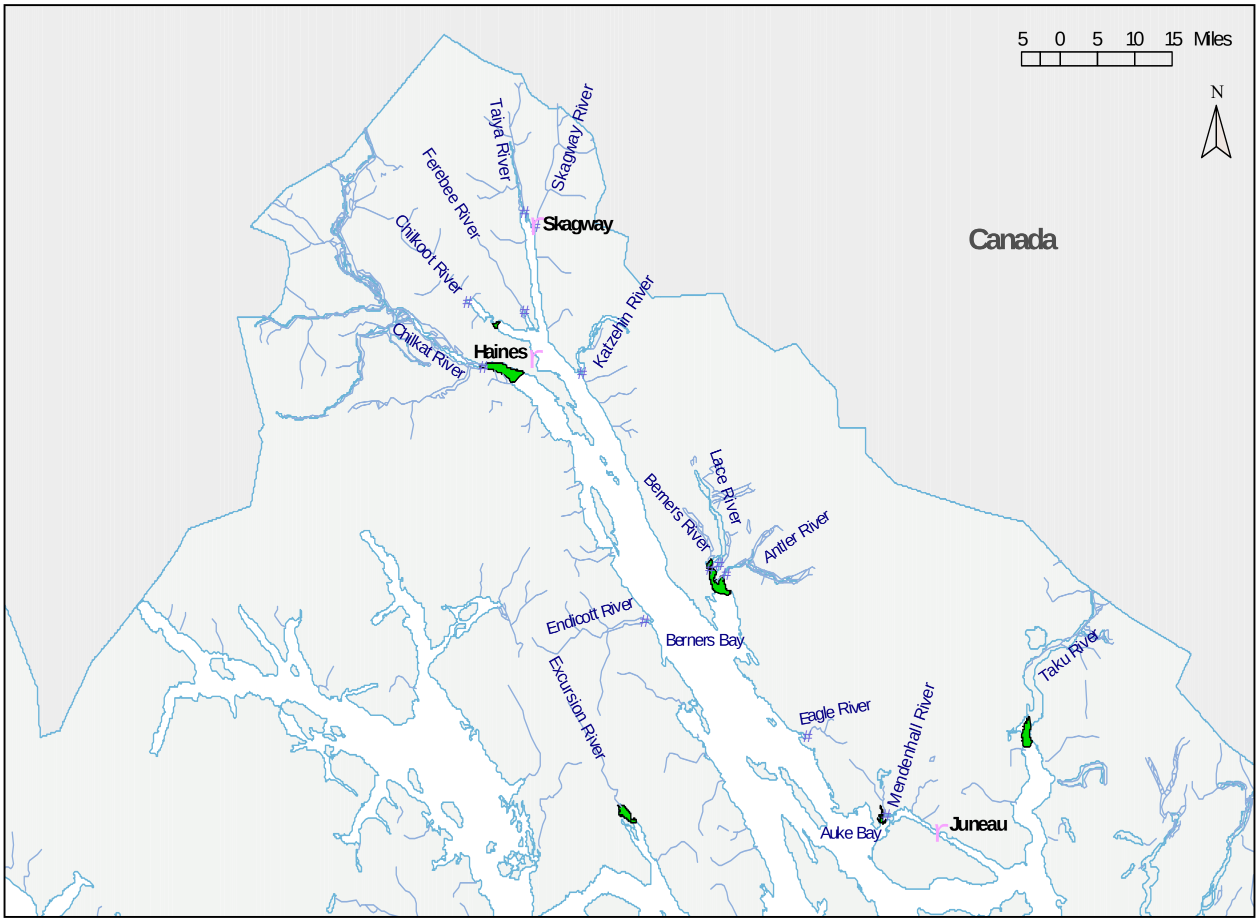

Figure 8. Location of documented eulachon runs in Lynn Canal (ADF&G MESA points in green; other runs from personal communications are denoted by purple circles)

Much of the recent ecological research on eulachon populations has been driven by potential threats to human subsistence harvests or the viability of ecologically dependent marine mammal populations. For instance, Betts (1994) conducted research on the contemporary Chilkat and Chilkoot River eulachon fishery in response to local concern over perceived declines in stocks in recent years and possible impacts to the Chilkat River run because of modifications to the Haines airport. Marston et al. (2002) published research on eulachon runs in the lower reaches of the rivers entering Berners Bay that suggested spring runs were an ecological cornerstone for regional coastal ecosystems that supported large numbers of wildlife species. Ongoing research in the Lynn Canal region has continued to focus on the ecological importance of eulachon runs in Berners Bay, primarily driven by the federal listing of Steller sea lions under the Endangered Species Act (Sigler et al., in review; K. Koski, NMFS unpublished report).

Although eulachon subsistence and personal harvest is regulated regionally in Alaska, it is becoming increasingly clear that populations are not genetically structured on a river-by-river basis, as would be expected for an anadromous species such as salmon (McLean et al. 1999; McLean and Taylor 2001). Genetic analysis of eulachon collected from 12 locations spanning the entire geographic distribution of the species (Bering Sea to the Columbia River) revealed that populations are characterized by low genetic variation comparable with some marine species. Other biological data, including data on meristics and river-specific spawning times, indicate substantial stock structure (Hay and McCarter 2000). Because little is known of eulachon life history, the mechanisms responsible for generating population subdivision are unclear. As a result, it is currently difficult to assign management or conservation units for this species using genetic data (McLean and Taylor 2001), and it is currently precautionary to assume stock structure is geographically discrete (Hay and McCarter 2000).

Stock assessment. The ADF&G has no formal stock assessment projects for eulachon in southeast Alaska. To the best of our knowledge, no historic quantitative assessments of eulachon biomass or run strength have been conducted in any of the Lynn Canal river systems. Historically, there were no specific management plans in place regarding subsistence fisheries in southeast Alaska, nor was biological research conducted because of the lack of commercial interest in the fishery (Betts 1994). However, cooperative studies involving multiple agencies (U.S. Fish and Wildlife Service [USFWS], U.S. Forest Service [USFS], National Marine Fisheries Service [NMFS], U.S. Geological Survey [USGS], and ADF&G) have recently been initiated to develop methods for population monitoring in the region (K. Koski, NMFS unpublished report). Some of the primary goals of this research are to establish index streams in Berners Bay and the Mendenhall River to develop a baseline of annual eulachon abundance that could be compared with marine mammal trends. Much of this work is being conducted as dissertation research by R. Spangler, USFS.

Stock status and trends. Because quantitative assessments are lacking, the status of Lynn Canal eulachon stocks is primarily based on anecdotal evidence or trends from other regions. Traditional harvesters have noted declines of eulachon runs in the Chilkat and Chilkoot Rivers (Betts 1994). Researchers studying Steller sea lion populations have hypothesized that declines may be linked to decreases in the quantity or quality of prey species such as eulachon (Sigler et al. in press). Genetic analyses indicate that eulachon populations throughout their entire geographic range constitute a single evolutionarily significant unit (McLean and Taylor 2001), thereby suggesting that population trends conducted in other regions may have some applicability to Lynn Canal stocks. In a status review of eulachon in Canada, Hay and McCarter (2000) point out that almost all spawning runs of eulachon from California to southeast Alaska have declined over the last 20 years, particularly since mid-1990s. Subsequent assessments of eulachon spawning stock biomass (SSB) in the lower reaches and estuary of the Fraser River estimate that SSB has varied from a minimum of approximately 100 tons in 1997 to a maximum of 1600 tons in 1996 (Hay et al. 2002).

Hypotheses Concerning Decline. In a review of factors causing declines in eulachon populations, Hay et al. (2002) implicates a variety of factors and suggests implementation of eulachon management policies that cover commercial fishery, forest industry, pollution, and habitat-alteration practices. Commercial and native fisheries maintained relatively large harvests for decades at consistent levels until severe restrictions were enacted in the 1990s in response to large declines in catches. Several important eulachon rivers (e.g., Fraser and Columbia) have been subjected to contamination by industrial pollution for a considerable period, and though pollution may have contributed to long-term declines, it "probably cannot account for the recent sharp declines" (Hay et al. 2002). Local habitat alterations that affect eulachon spawning habitat, such as dredging, forest practices, and log booms, also appear to be the likely cause of local impacts in some systems but not the widespread declines observed in recent years. Bycatch of eulachon by offshore shrimp trawling operations (15 to 20 tons in some years) was also considered a possible factor in limiting the recovery of certain stocks, although it comprised a relatively small proportion of the spawning biomass. Changing ocean conditions associated with an increase in sea-surface temperatures off the coast of British Columbia into the late 1990s may also mediate changes in eulachon prey composition and availability or the distribution and abundance of predators. Previous studies by Hay et al. (1997) showed that synchronous changes among different eulachon populations may reflect geographically widespread ocean changes.

3.2.4 Summary Habitat Requirements

A conceptual model (Figure 9) summarizes patterns of eulachon habitat distribution and use by life history stage, and provides the foundation for subsequent analyses of ecological effects.

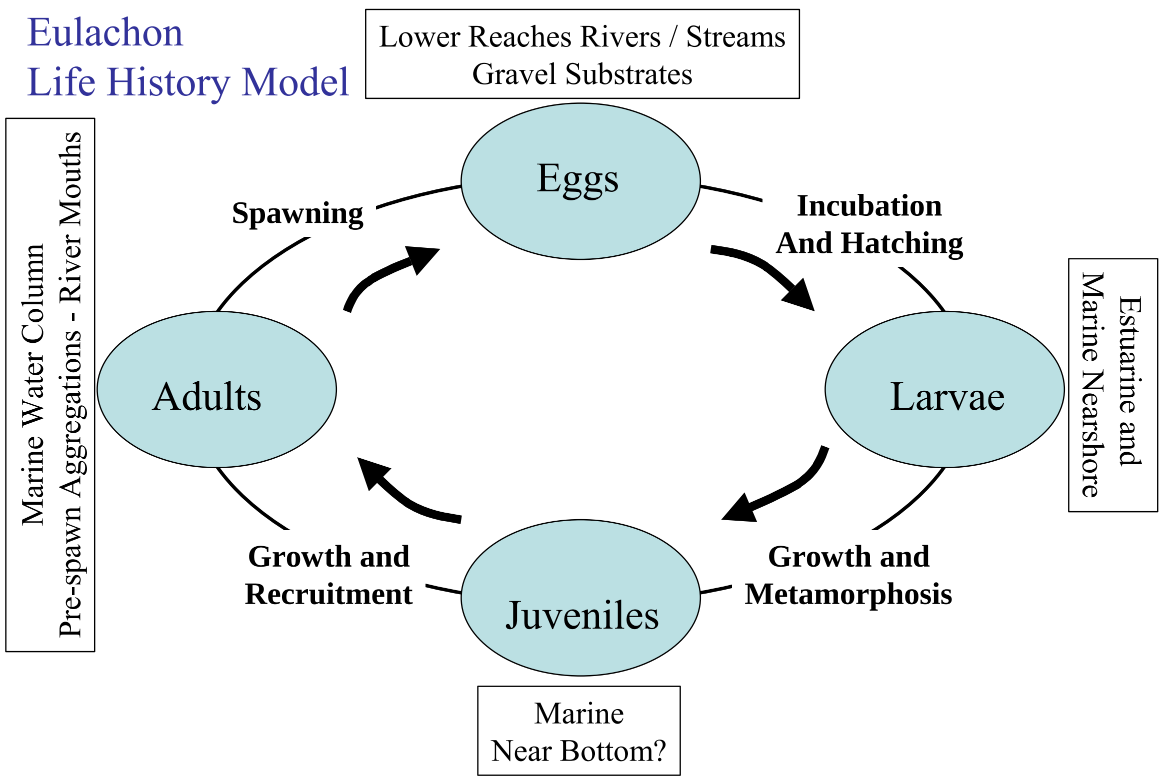

Figure 9. Summary of habitat requirements and processes associated with major life-history stages of eulachon.

3.3 Ecological Role of Lynn Canal Forage Fish

Herring and eulachon populations are critical links in the marine food web and are viewed as necessary to ensure healthy populations of predatory fish, marine birds, and marine mammals (Hebert and Pritchett 2002). Not only do forage fish provide a high energy density prey source, but their spring spawning aggregations occur at a time when many predators have high energetic costs after a prolonged winter fast. Naturalists have often noted large concentrations of marine mammals, avian predators, and terrestrial mammals in areas with eulachon runs or herring spawn (Marston et al. 2002). Though not the focus of this paper, it would be remiss to not mention some key points about the role of forage fish in regional ecosystems.

Berners Bay has frequently been noted as a biological "hot spot" where eulachon and herring are the key species in the food web, especially in the spring when many predators break their winter fast and have high energetic demands before breeding (Marston et al. 2002). Ongoing research suggests that seasonal movements of Steller sea lions in Lynn Canal are guided by temporal peaks in the abundance of herring and eulachon (Sigler et al. in press). Radio-tracking showed that sea lions fed on resident Lynn Canal herring stocks during the winter before moving into Berners Bay to target local eulachon runs in mid-April, followed by Haines area eulachon runs in May, before finally moving to outer coast locations to pup (personal communication, M. Sigler, NMFS Auke Bay). Daily average peaks of over 250 sea lions and harbor seals, 40,000 gulls, 600 bald eagles, and thousands of other seabirds have been observed in April and May of some years, targeting the spawning aggregations of herring and eulachon in Berners Bay (Marston et al. 2002, USFWS 2003). Other terrestrial mammals (e.g., wolves, bear, wolverine) use Berners Bay tide flats and riparian zones as an important foraging and migratory corridors (personal communication, Ed Grossman, USFWS Juneau). Similar, but less well-documented predator aggregations have been observed feeding on eulachon spawning runs in Lutak and Chilkat Inlets near Haines, including coordinated hunting by hundreds of sea lions (personal communication, Randy Bachman ADF&G).

4.0 Potential Environmental Stressors

The following discussion provides a comprehensive, though not exhaustive, review of the literature on the vulnerabilities of these species to environmental variables (Table 3). Both Pacific herring and eulachon have life-history stages that make them vulnerable to a variety of environmental hazards, in particular to shore-based activities from which impacts extend into shorelines, nearshore areas, and lower-river reaches. Because it is generally accepted that the earliest stages are the most vulnerable, the majority of previous studies have focused on egg and larval stages. This section reviews the literature for potential stressors. Project specific assessment of potential effects appears in Section 5.0.

4.1 Fishing/Harvest

Because herring fisheries have concentrated on exploiting herring for roe since the 1960s, adult herring come under significant harvest pressure as they school in nearshore spawning areas (Emmet et al. 1991). The vulnerability of adult spawners to overharvesting has led to strict management of the fishery. Despite these measures, populations continue to fluctuate, and several populations throughout the world have collapsed. Pearson et al. (1999) reviewed literature on the causes of herring stock collapses throughout the world and reported that overfishing was the most frequent reason given (74% of 46 cases). Although overfishing was listed as the sole cause in 37% of the cases, many reported that environmental factors (e.g., density-dependent responses, changes in food supply) acted in concert with overfishing (37% of cases).

Eulachon has lacked the high profile that herring has among Pacific coastal fisheries, and therefore has received substantially less study. Eulachon has long supported subsistence fisheries for coastal Aboriginal cultures, as well as commercial and recreational fisheries on the Columbia River, Fraser and Nass Rivers (Hart 1973), and Klamath River (Moyle 1976 in Emmet et al. 1992) this past century. Eulachon captured as bycatch in shrimp trawl fisheries may inhibit the recovery of depressed stocks (Hay and McCarter 2000).

Table 3. Potential Factors that May Affect Herring and Eulachon Populations

Fishing / Harvest
Water Quality: • Petroleum / Poly-aromatic hydrocarbons (PAH) • Other Contaminants • Nutrients • Salinity, Temperature • Turbidity
Habitat Alteration: • Altered Wave Energy • Light/Humidity Regime • Depth/Slope • Sediment Characteristics • Hydrology
Human Disturbance
Disease
Predation
Prey
Climate Change
Stochastic Population Dynamics

4.2 Water Quality

4.2.1 Petroleum / Polycyclic Aromatic Hydrocarbons (PAH)

Several studies have been conducted to investigate the effects of petroleum hydrocarbons on the various life-history stages of Pacific herring. The egg stage has been shown to be the most sensitive to petroleum hydrocarbons, with direct contact with oil providing the severest damage scenario (Pearson et al.1999). Hay et al. (1995) also found that eggs deposited on oiled vegetation suffered the highest level of effects. Carls et al. (1999, 2000) tested the response of various life-history stages to artificially weathered crude oil. Herring eggs directly exposed to 0.7 µg/L total polycyclic aromatic hydrocarbons (TPAH) of weathered oil caused malformations, genetic damage, mortality, decreased size, and inhibited swimming in hatched larval herring. Total aqueous PAH as low as 0.4 µg/L caused other sublethal responses (e.g., yolk-sac edema and precocious hatch / immaturity). These very low thresholds are currently under debate, however, because of the possible effects from confounding toxicants produced in the experimental system (Pearson 2002).

Larval herring are also more sensitive to PAH exposure than adult herring. Carls (1987) tested the response of larval herring to direct exposure to water-soluble fractions (WSF) of crude oil and indirect exposure via consumption of oil-contaminated prey. Concentrations of 0.9 ppm WSF caused high levels of mortality and reduced swimming and feeding rates. Exposure to lower fractions over time reduced larval length and weight (by Day 7 to 0.7 ppm and by Day 14 to 0.3 ppm). Ingestion of highly contaminated prey (6 ppm) caused significant mortalities. Such levels are high even for an oil spill. However, the unlikelihood that prey will actually encounter such exposures and the fact they are able to depurate most WSF within one day led the author to determine that contaminated prey are not likely to be a significant route of contamination.

Studies by Rice et al. (1987 in Carls et al. 1987) found adult spawning herring to be less sensitive to WSF of crude oil than eggs, yolk-sac larvae, and feeding larvae with a significant mortality response at exposure levels of 27 µg/L. Progeny produced from reproductively mature herring exposed to a 16-day aqueous PAH of ≤58 µg/L were generally not affected, even when concentrations reached 9.7 µg/g in the ova. The authors suggest this lack of response is due to chemical partitioning in adult tissues – passing less-toxic fractions to the gametes, and depuration by gametes at time of spawning.

Recent studies caution that certain oil products, weathered oil, and PAH may be 2 to 1000 times more toxic when exposure occurs in combination with natural light (termed "photoenhanced toxicity") (Barron and Ka'aihue 2001; Barron et al. 2003). For photoenhanced toxicity to occur, three conditions must be met: PAH tissue burden, UV exposure, and tissue transparency. Fish embryos and larvae are likely more susceptible to photoenhanced toxicity than adults because of their lack of pigment (Barron and Ka'aihue 2001). However, many question the ecological relevance of phototoxicity (Swartz et al. 1997; Boese et al. 1999). Whereas photoenhanced toxicity of PAH has been well characterized in controlled studies, it has not yet been confirmed as a cause of mortalities in the field. Indeed, because of the uncertainties surrounding the actual occurrence of phototoxicity under field conditions, McDonald and Chapman (2002) caution against using phototoxicity in environmental decision making until issues regarding its reality in the field are resolved.

4.2.2 Other Contaminants

To determine the cause of an apparent change in the normal migratory pattern of the Cowlitz River eulachon run up the Columbia River mainstem, a study by Smith and Saalfield (1955) measured the directional responses of migrating fish to various dilution levels of three industrial effluents: sulfate-based effluent discharged by a fiber company, mixed sulfate-sulfite waste discharged by a timber pulp company, and fluoride-based effluent from an aluminum company. In each experiment, fish showed a significant preference for unaltered waters over those altered with varying dilutions of effluent, suggesting that exposure to certain contaminants can lead to altered migration routes.

The high lipid content of eulachon make them potential accumulators of lipophilic organic contaminants. In 1986 and 1988, Rogers et al. (1990) found that eulachon tissues and water samples in the lower Fraser River and estuary contained various industrial waste compounds, such as chlorophenols from wood preservation operations and chloroguaiacols from pulp bleaching. Whole fish samples contained dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD) and concentrations of these contaminants, as well as concentrations of pentacholorophenol, 3,4,5-trichloroguaiacol, and tetrachloroguaiacol in whole bodies, livers, and gonads showed an increasing trend with distance upriver.

4.2.3 Nutrients

Nutrient enrichment in receiving nearshore waters may cause significant changes in intertidal and subtidal plant communities. A shift to phytoplankton or bloom-forming macroalgae may form dense mats over existing perennial macrophytes. These nuisance algae are typically filamentous (sheet-like) species (e.g., *Ulva*, *Cladophora*, *Chaetomorpha*) that, if persistent, can ultimately displace seagrasses and perennial macroalgae through shading effects (NRC 2000). Aneer (1985) discusses a possible link between higher egg mortalities in Baltic herring spawn on filamentous algae (75%) versus coarser algae (33%) as a result of greater oxygen depletion at night on filamentous algae, and suggests that the nutrient increases to the Baltic Sea since the mid-1960s has resulted in an increase of filamentous algae. Consequently, there has been a significant reduction in the biomass and abundance of bladder wrack, which previously constituted 99% of the total plant biomass.

4.2.4 Salinity and Temperature

Pacific herring embryos and larvae show a euryplastic (broad) development response to different environmental conditions (Alderice and Hourston 1985). A study by Alderice and Velsen (1991) found that incubating eggs tolerate a wide range of salinities and temperatures. However optimum ranges for incubation success are 12‰ to 17‰ at 6.5ºC to 8.3ºC. Early larval development success, (i.e., length at hatching and growth rate), appears highest at 13‰ to 21‰ at 5.5ºC to 12ºC. Within these optimal ranges, incubation success is also related to the relationship between salinity and temperature. Lower salinity coupled with lower temperatures, and higher salinity coupled with higher temperatures, provide the greatest incubation success.

Salinity levels affect the thickness of the jelly coat surrounding the herring egg. Very low salinities (5‰) cause the coat to be very thick and may reduce necessary water flow through egg mass (Alderice and Hourston 1985). Conceivably, high freshwater pulses during incubation periods may thus inhibit the ability of the developing embryos to receive sufficient oxygen and remove metabolic wastes. Observations by Taylor (1971 in Alderice and Hourston 1985) that eggs had higher levels of survival at lower salinities when exposed to three different concentrations (10‰, 20‰, and 30‰), led Alderice and Hourston (1985) to suggest that reduced tolerance to high salinities may be due to the concurrent reduction of oxygen saturation.

Adult eulachon were tested for sublethal and lethal responses to temperature increases by Bahm and McConnell (1971). Initial tests exposed fish to sudden increases in temperatures for 1 h to simulate exposure to a thermal plume. Over 50% of the fish died within 1920 min when exposed to temperatures 8ºC or more above the control (acclimation) temperature of 10ºC. Exposure to 32ºC caused 100% mortality within 20 seconds. Subsequent tests used 5ºC as the acclimation temperature and exposed fish to a series of elevated temperatures until death or until termination of the test at 8 days. A 50% mortality was reached when temperatures were increased by 6ºC (to 11ºC) after 8940 min, and 100% mortality was reached at 26ºC and 29ºC within 1.5 minutes. At temperatures ranging from 23ºC to 29ºC, a stress-panic reaction ensued and swimming was no longer directional. Thus fish would unlikely be able to escape thermal plumes at these temperatures of their own volition. Significantly, gravid females exposed to test temperatures retained their eggs until death or until the conclusion of the tests, whereas control fish deposited viable sperm and eggs in the tank. This observation suggests that increased temperatures might alter the spawning cycle of eulachon, but the temperature changes required to do so would have to be substantial, that is, warming from 5ºC ambient to a new ambient of 11ºC within 8 days.

4.2.5 Turbidity and Suspended Solids

Herring eggs, like salmonid eggs, appear to require high ambient oxygen levels in perfusing water prior to hatching. Alderice and Hourston (1985) suggest that incubating herring eggs require a minimum ambient oxygen level of 2.5 mg/mL. Although herring eggs are likely more efficient at oxygen transfer than salmonid eggs because of greater surface area per unit volume, a low perfusion velocity of water moving past the eggs can limit respiration, potentially impacting the developing embryo (Alderice and Hourston 1985). This might explain observations that herring select spawning substrate free of silting (Section 3.1.1), as increased sediment loads may suffocate incubating eggs.

Post-hatch larval herring (10 to 22 day old) were subjected to different concentrations of sediment suspensions to determine the effect on feeding ability (Boehlert and Morgan 1985). At the lower concentrations tested, feeding was greatest at sediment suspensions of 500 mg/L and then sharply declined at higher suspensions. Although this observation suggests that some concentrations of suspended sediment may actually enhance feeding, potentially by providing visual contrast of prey while providing protection from larger predators, very high sediment loads depress feeding in early larval stages.

4.3 Habitat Alteration

Williams and Thom (2001) conducted a comprehensive literature review of the effects of shoreline modifications on nearshore processes and the ecology of nearshore-dependent species in the Puget Sound, Washington. Any structural modification along the shoreline may alter important physical processes. Impacts from shoreline modifications may be considered direct, indirect, and cumulative (Table 4). Direct physical disturbance is associated with in-water and beach construction activities and includes noise caused by heavy equipment use (e.g., pile driving) (Section 4.4), potential water pollution (Section 4.2.1) and increased sediment suspension (Section 4.2.5). Other immediate impacts associated with in-water construction activities include burial or excavation of intertidal and subtidal habitats (e.g., in-water fill and dredging).

Table 4. Effects of Shoreline Armoring on Physical Processes (adapted from Macdonald et al. 1994).

Direct Impacts a. Temporary Construction Effects b. Permanent Effects – Placement of Structures/Loss of Beach Fill – Impoundment (Loss of Sediment Source Behind Structures)
Indirect Permanent Effects a. Downdrift Permanent Effects from Sediment Impoundment b. Modifications of Groundwater Regime c. Hydraulic Effects from Armoring – Increased Energy Seaward of Armoring – Reflected Wave Energy from Other Structures – Dry Beach Narrowing/End Wall Effects – Substrate Winnowing/Coarsening – Beach Profile Lowering/Steepening – Potential "During Storm" Effects – Sediment Storage Capacity Changes – Loss of Organic Debris – Downdrift Effects of the Above
Cumulative Effects a. Incremental Increases in All Effects b. Effects to Single Drift Sectors – Downdrift Sediment Starvation c. Potential Threshold Effects

Indirect impacts can result from structural shoreline modifications that permanently alter physical processes. Chronic changes in regional hydrology alter wave energy and current patterns, obstruct littoral drift and longshore sediment transport, and cause fluctuations of temperature, salinity, and water levels. In turn, these changes can further alter substrate characteristics and beach morphology and affect biological resources and processes, such as changes in vegetation, primary production, food-web dynamics and predator-prey interactions.

Modifications to the nearshore that increase wave energies in tidal areas have potential to exacerbate the loss of spawn. Spawn deposited in intertidal regions will naturally experience greater wave energies than spawn in subtidal areas, and increased wave energies during storms can further increase egg mortality. Rooper et al. (1999) found that 74% of exposed spawn on a single transect was lost during a storm event. Slightly lower values of site-specific, wave-induced loss have also been estimated at 26% by Hart and Tester (1934 in Rooper et al. 1999) and 40% by Hay and Miller (1982 in Rooper et al. 1999).

Depth of spawn is important in determining egg loss. Rooper et al. (1999) found that eggs that survived to hatching were deposited at a depth of from 1 m to -4 mean lower low water (MLLW). Using a model of estimated cumulative time of air exposure over incubation as a proxy for depth, the estimated loss from spawning until hatching was 67% to 100%, with an average of 75% in 1995. Spawn in the upper intertidal is likely to be more susceptible to desiccation and other stressors, such as wave energy and predation. Spawn at increasing depth may also be susceptible to higher rates of loss. Taylor (1971 in Alderice and Hourston 1985) reported an inverse relationship between hatching success and increasing depth (0, 5, 10 m). This loss rate at greater depths may be a result of a combination of factors, including reduced oxygen and higher levels of fish predation. Similar to alterations in wave energies, alterations in beach morphology (e.g., steepening) and substrate (e.g., changes in vegetation) caused by shoreline structures may further increase mortality in herring spawn.

4.4 Disturbance

Human disturbance can take many forms and can potentially impact aquatic resources, depending on the type and severity of the disturbance. One such possible disturbance to adult herring and eulachon is underwater sound generated by human activity (e.g., watercraft). Schwarz and Greer (1984) found that Pacific herring are capable of selective and directional responses to sounds and that response duration and intensity is most affected by the magnitude, direction, and rate of change of amplitude. For example, when subjected to sounds of a fishing fleet, herring showed an avoidance response to sounds generated by large vessels approaching at constant speed and to smaller vessels only on an accelerated approach. Fish held in farm pens for two months prior to the study showed no response to the sounds of a variety of boats moving about in the vicinity of the pens. However, the herring showed the least habituation to large approaching vessels. Herring showed no negative response to taped sounds of natural origin, such as gull cries or barks of Steller sea lions, or to sonar or echo sounders. Herring appear to habituate to sounds with a slow rise time in the environment, but show no habituation to sounds with abrupt signatures (Blaxter and Hoss 1981). Therefore, vessel traffic with loud, abrupt sound signatures may induce startle or alarm responses, resulting in changes to herring distributions. Whether marine vessels (e.g., fishing fleets) will cause herring to avoid spawning areas has not been demonstrated.

Noise and human movement or activity in spawning channels are factors that may inhibit the upstream movement and spawning of eulachon (Betts 1994; personal communication, Randy Bachman ADF&G).

4.5 Disease

Disease can strongly affect herring recruitment and adult population abundance. Marty et al. (2003) found that the pathogen, *Ichthyophonus hoferi,* contributes to mortality in older fish, as its prevalence increases within a year class as it ages. Viral hemorrhagic septicemia virus (VHSV), however, contributes more to mortality in younger fish, thus influencing recruitment and overall population dynamics. An epidemiological study of the herring population in PWS from 1994 to 2002 by Marty et al. (2003) indicates that poor body condition in early spring was perhaps the most important risk factor preceding two distinct epidemics in the 1990s. The reason for poor body condition was attributable to different factors. Pearson et al. (1999) report that PWS herring entered the winter of 1992-1993 with inadequate energy stores following a summer of high population biomass and poor growth. The following VHVS epidemic killed about 75% of the PWS population. In the epidemic of the late 1990s, an El Niño winter produced water temperatures on average 2ºC warmer than the previous winter, increasing metabolic demand of overwintering herring (Foy and Norcross 2001). Although the fish entered the winter of 1997-1998 in good condition, food resources were not great enough to meet this increased demand (Foy and Norcross 2001), resulting in depressed overall body condition by spring and a high prevalence of VHSV and ulcers.

4.6 Predation

Herring are a major forage fish, and their abundance at fairly high levels is viewed as necessary to ensure healthy populations of predatory fish, marine birds, and marine mammals (Hebert and Pritchett 2002). Significant losses of eggs can occur in the intertidal zone from bird predation. Alderice and Hourston (1985) cite observations of gulls consuming 40% to 60% of exposed eggs within 3 days of deposition. Haegele et al. (1981) cautions, however, that these estimates only apply to exposed eggs, and therefore, the actual loss of total spawn from bird predation is likely only about 10%. According to Outram (1958 in Haegele and Schweigert 1985), avian predation rates upwards of 40% are likely only if the spawn is large and on shallow slope beaches. In areas that receive consistent annual rates of avian predation, loss from predation will be proportionately higher during years of low spawning (Bishop and Green 2001). Subtidal eggs are preyed on by diving ducks, although their consumption rate appears to be considerably less than intertidal loss from gulls. Ducks also tear loose vegetation with spawn. These eggs likely don't survive desiccation and predation (Alderice and Hourston 1985). Bishop and Green (2001) examined bird diets of the five most abundant avian species in PWS in 1994 and calculated that these species consumed 31% of the estimated spawn biomass. Other consumers of spawn include invertebrates, marine mammals, and fishes (Bishop and Green 2001).

Recent increases in harbor seal populations have also been implicated in the declines of some local herring stocks in British Columbia (personal communication, D. Hay, DFO Canada). Natural mortality has been inversely related to biomass, or depensatory, in Strait of Georgia herring stocks (Stocker et al. 1985). The principle mechanism suggested for depensation is increased natural mortality as a result of predation associated with smaller herring school sizes at low biomass (Clark 1974 in Stocker et al. 1985).

Larval herring may be a significant food source for jellyfish medusae, a variety of other pelagic invertebrates, outmigrating juvenile salmon, as well as juvenile and adult herring (Hourston and Haegele 1980). Although little is known about predation on juvenile herring, schooling adults holding inshore and during spawning are prey of salmon, sea lions, seals, Orcas, dogfish, and birds (Hourston and Haegele 1980). Offshore predators include salmon, hake, sablefish, Pacific cod, and dogfish.

Recent surveys on the predator abundance response to eulachon spawning runs in Berners Bay suggest that spring spawning runs of eulachon and other forage fish are "an ecological cornerstone for regional coastal ecosystems" (Marston et al. 2002). Surveys conducted during spring spawning runs in 1995 and 1996 showed that predator abundance rose quickly with the arrival of the eulachon and significantly tracked eulachon abundance within years. Avian predators were in greatest abundance and reached a daily average maximum of 40,000 in 1996 and 25,000 in 1997. Overall, gulls were the most abundant and foraged primarily on fish migrating upriver. Bald eagles numbered close to 600 but fed mainly later in the run on dead or weakened, spent fish. Steller sea lions and harbor seals averaged daily peaks of 250 and foraged early in the run. The large spawning runs provide predators with a high-energy source of rather easily captured prey at a time when many species have high-energy costs (i.e., sea lions increasing energy reserves prior to birthing and avian species utilizing energy reserves during migrations and reproduction [Marston et al. 2002]).

4.7 Prey

Lasker (1985) reported that herring larvae are susceptible to starvation because they may "give up" if unable to feed soon after hatching. McGurk (1985) estimated that starvation occurs in 18% to 36% of first feeding larvae. According to McGurk et al. (1993), stocks at low density are probably not limited by food but by other factors, such as incubation conditions (e.g., desiccation, extremes of temperature, predation). In general, herring survival during early stages is dependent in part by stable current patterns that retain larvae in favorable feeding areas (Stevenson 1962).

Studies in PWS (1994 to 1995) found that the overlap of YOY herring prey with YOY walleye pollock was high in both allopatric and sympatric species, and non-feeding was greater in sympatric fish. These results indicate a potential for competition and may be a factor in regulating populations of sympatric fish if prey resources decline (Sturdevant et al. 2000). Foy and Norcross (1999) found that the diet of cohorts of juvenile herring varied in composition and density across four bays sampled each season in PWS. Smaller, age-0 herring were estimated to be assimilating food near maintenance levels prior to approaching critical overwintering periods. Thus, access to adequate prey during spring and summer is critical for YOY, and most likely juvenile, herring to assimilate sufficient energy stores to overwinter.

4.8 Ocean Climate and Stochastic Processes

Fluctuations in clupeoid populations and the mechanisms that determine year class strength are a subject of debate and considerable research (Lasker 1985). Lasker (1985) lists several studies that posit theories on these mechanisms: the "critical period" between post yolk-sac stage and first feeding (Hjort 1913), interspecific interaction (Lasker and MacCall 1983), cannibalism (MacCall 1980), larval drift (Parrish et al. 1981 and others), variation in egg survival (Lo 1984), changes in fish fecundity (Piquelle and Hewitt 1983), effect of localized oceanographic events (Lasker 1975 and 1978), and widespread oceanographic events (e.g., El Niño, Valdivia 1978). Lasker (1985) concluded that clupeoid production appears to be limited by "almost everything," and that that future studies are needed to determine what limits clupeoids the most and at what life stage.

Recently, larger data sets on fisheries recruitment have enabled fisheries scientists to examine possible mechanisms of population fluctuations occurring on interannual and decadal time scales. Regionally, Hay and Kronlund (1987) correlated sea-surface temperatures in the Strait of Georgia with spawn deposition and found that there is a 4-year lag such that deposition was most sensitive to sea-surface temperatures 4 years prior to the spawning. They suggest that temperature, in some way, is correlated with another factor that affects recruitment. Yet the combined effect of sea-surface temperatures and total catch, although significant, accounts for only 32% of the variance (Hay and Kronlund 1987). Further, studies in southern British Columbia indicate that herring year-class strength is negatively correlated with warm conditions, which appear to reduce herring zooplankton food resources and increase predation on herring (Ware 1992). Similarly, Hollowed and Wooster (1995 in Brown 2002) found high correlation between cool years (associated with a weakened Aleutian Low) and higher-than-average recruitment for Vancouver Island, British Columbia.

The opposite climate/recruitment relationship in herring recruitment, however, has been documented in Southern Alaska and the Gulf Alaska, indicating a north-south difference in response of herring to climate condition, similar to that seen in salmon production. Zebdi and Collie (1995 in Brown 2002) found herring recruitment in Southeast Alaska to be positively correlated with warm, wet climate conditions associated with an intensified Aleutian Low. Several studies on Gulf of Alaska populations (e.g., Brown 2002) document similar “in-phase” trends between abundance and decadal-scale climate indices, specifically the Atmospheric Forcing Index and Aleutian Low Pressure Index, the Pacific Inter-Decadal Oscillation, and the winter season Pacific Decadal Oscillation. The positive phases of these indices correspond generally to higher sea-surface temperatures and storm frequency within the Gulf of Alaska. Brown (2002) also points out that the greater water-column stability associated with a strong Aleutian Low provides conditions conducive to higher rates of primary and secondary production, which may, in turn, lead to a positive response in zooplankton and herring production.

Despite the links of Pacific herring population to climate variations, small-scale fluctuations (i.e., between years within the same stock and between stocks within the same region) remain evident. The following excerpt by Cooney et al (2001) in a review of Kendall and Duker (1998) perhaps best describes our current state of understanding on the various environmental factors that influence marine fisheries populations:

> “… even with substantial advances in technology and published results of others to exploit, many of the questions, concepts, and hypotheses posed to explain recruitment variability remain unsolved.”

5.0 Potential Ecological Effects

In this section we summarize typical highway and marine transportation facility activities and identify the pathways by which these activities could impact Pacific herring and eulachon. We use available information to identify potential ecological effects to these forage fish populations, review the cumulative effects of past conditions that have likely led to their current status, and then provide a brief overview of the most relevant project-related risks to forage fish populations in Berners Bay. We conclude with a summary of the major discussion points.

5.1 General Project Characteristics

To facilitate examination of the potential stressors that SDEIS alternatives could be to herring or eulachon populations in Lynn Canal, we attempt to broadly characterize project activities associated with typical highway and marine transportation facilities, as follows.

Typical Highway Construction, Maintenance, and Operations Activities

- Construction of a highway near shoreline
- Blasting and excavation near shoreline
- Placement of in-water fill materials into intertidal and subtidal areas
- Construction of bridges
- Sanding and deicing of the highway
- Stormwater runoff

Typical Marine Terminal Construction, Maintenance, and Operations Activities

- Pile driving
- Dredging and disposal of dredged material

- In-water fill for staging and terminal facility or breakwater construction
- Release of treated sewage effluent
- Wake, propeller scour, turbidity, and underwater noise from ferry operations

In addition to these typical activities, there can be accidental spills of fuel and other hazardous materials during construction, maintenance, and operation of ferry terminals and highways.

5.2 Pathways of Exposure

Proper characterization of ecological effects involves a thorough knowledge of the: 1. problem, 2. assessment endpoints relative to the resources of concern, 3. vulnerabilities of these resources to hazards or stressors, and 4. pathways of exposure (Figure 1). In this section we synthesize and interpret available information to make some assessments about the likelihood that activities associated with typical highway and marine transportation facilities could impact Pacific herring or eulachon. We emphasize that because little specific information exists for quantitative analysis (e.g., dose-response curves, quantitative relationships of population response to specific impacts) our assessment is based on an analysis of the potential exposure pathways and on our best professional judgment.

The conceptual models presented in Figures 7 and 9 clarify the distribution and use of various habitats by species' life history stage (Section 3.0). Both species use a variety of habitats through ontogeny, with spawning events and early life history stages more closely associated with nearshore habitats. Findings from other studies identify the potential stressors that affect eulachon and herring at the organism and population level (Section 4.0 of this document). Both Pacific herring and eulachon have life history stages that make them vulnerable to a variety of environmental hazards, in particular to impacts along shorelines and in watersheds that affect nearshore physical processes and habitat structure. An understanding of the characteristics associated with typical highway and marine transportation facilities and potential exposure pathways provide the necessary guidance for making an informed analysis of likely risks to Pacific herring and eulachon populations (see SDEIS EFH Assessment Technical Report).

Direct effects include those generally associated with construction activities (e.g., dredging and placement of in-water fill). These impacts may often be mitigated through the use of best management practices (BMPs) that time activities in such a way as to avoid or minimize exposure by the resources of concern. Indirect effects occur following physical changes and are chronic in nature as a result of permanent alteration of physical processes (e.g., wave energy, hydrology, light levels). This report focuses on the potential direct effects on forage fish in Lynn Canal that would be associated with typical highway and marine facilities. Cumulative effects are associated with increasing number or size of indirect or direct effects, to which there can be either linear or nonlinear cumulative responses. Cumulative effects are addressed in the SDEIS EFH Assessment and Cumulative Effect Technical Reports using the information in this report and other sources.

5.2.1 Highways

Highways that are constructed on marine shorelines and in the lower reaches of coastal watersheds have the potential to impact herring and eulachon life-history stages that use nearshore marine habitats and river systems.

5.2.1.1 Water Quality

The construction, maintenance, and operation of highways can be a source of pollutants that reach local water bodies and impair water quality. Blasting and excavating during construction may temporarily affect local watersheds by increasing sediment suspension in runoff to neighboring streams and nearshore areas. Highway maintenance practices, such as sanding and deicing (generally done only at heavily used urban intersections), can be a seasonal source of contaminants.

Most chronic pollutants associated with highways are use-related and attributed to vehicular sources (Forman et al. 2003). For example, an assessment by Kobringer and the Federal Highway Administration (1984, 1996 in Forman et al. 2003) found that vehicles provided 83% of the various pollutant constituents of stormwater runoff (Figure 10). The fate of these contaminants in receiving waters depends on a number of factors, including the volume of traffic, rainfall, and size of the receiving water. High-traffic urban highways (average daily traffic greater than 30,000 vehicles) in general contribute four to five times more pollutant levels than low-traffic rural highways (Driscoll et al. 1990, Federal Highway Administration 1996 in Forman et al. 2003). Acute, but less frequent, contributions involving accidental spills of oil, gasoline, and industrial chemicals may occur during highway construction and operations.

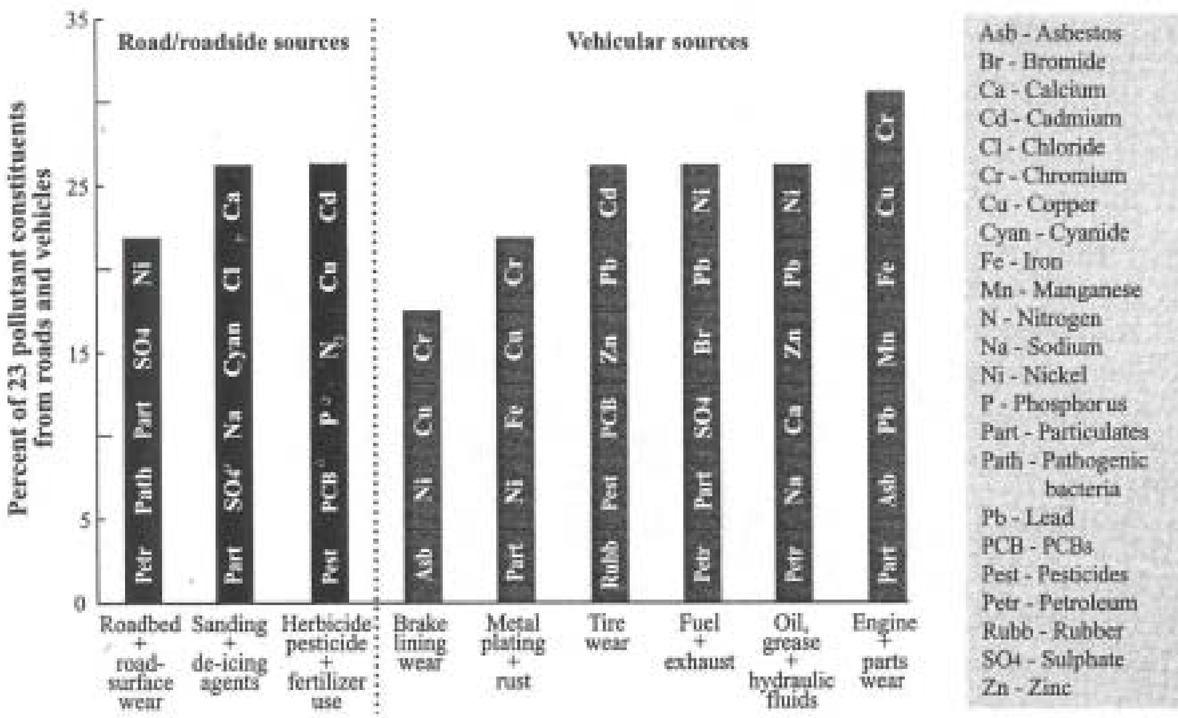

Figure 10. Sources of road related contaminants in stormwater runoff (source: Forman et al. 2003)

Herring egg and larval stages are sensitive to petroleum constituents and have some potential to be affected if highway runoff and herring spawn or larvae habitat overlap (Table 5). The most severe effects would be from direct exposure to contaminants, as with a highway spill flushed to the nearshore where spawn or larvae are located. Knowledge of runoff composition, concentration or dilution, and mixing rates would be needed to better inform likely exposure and risk assessment.

Vegetated buffers can filter nutrients, bacteria, and other pollutants from surface waters, and also moderate the effects of stormwater runoff, soil erosion, and water-level fluctuations (Desbonnet et al. 1994). The functional effectiveness of high-quality buffers increases substantially when they are at least 75 meters (246 ft) in width (Desbonnet et al. 1994). Furthermore, watershed imperviousness has been positively related to pollution in lowland stream systems (May et al. 1997), and in the absence of existing data, this relationship could be applied to marine nearshore systems. Watershed impervious surface areas correspond to the following urbanization categories as follows): commercial (90% total impervious area [TIA]), high-intensity residential or urban (60% TIA), medium-intensity residential or suburban (35% TIA), and low intensity residential or rural (10% TIA) (May et al. 1997, May and Peterson 2003). Therefore, highways in a low intensity rural setting (<10% TIA) would likely contribute fewer pollutants to nearshore receiving waters.

Contaminants in highway runoff or accidental spills have the potential to affect spawning adult eulachon and their eggs in receiving waters near bridge crossings where historic eulachon spawning has occurred (Table 6). Although we found no evidence in the literature of eulachon avoiding waters receiving stormwater, adult eulachon have shown a preference for unpolluted waters when migrating upriver to spawn and have been shown to forego historical spawning areas that are affected by industrial pollution. As demonstrated with herring (Carls et al. 1999), eulachon embryo development could also potentially be affected by accumulated contaminants in sediment.

In addition to being possible sources of contaminants, concentrated highway runoff has the potential to increase turbidity from roadside erosion, alter salinity and temperature regimes, and cause nutrient loading in local streams and nearshore receiving waters (Forman et al. 2003). Elevated turbidity may suffocate herring eggs, which require high ambient oxygen levels, and inhibit feeding of early stage larvae (Table 5). Turbidity is unlikely to be a factor affecting adult eulachon, which often spawn in highly turbid glacial rivers, although eggs could be suffocated by heavy loads of fine sediment suspended during construction activities (Table 6). Herring eggs could be susceptible to the effects of nuisance algae blooms caused by nutrient enrichment (Table 5), although this problem would be limited to poorly flushed areas with extremely high nutrient loading rates. Egg and larval development can also potentially be affected by dramatic shifts in water salinity (herring only) or temperature (both herring and eulachon) mediated by highway runoff, although this situation would be unlikely under most circumstances.

5.2.1.2 Habitat Loss / Alteration

Coastal highway construction can involve direct alterations to marine shorelines, subtidal and intertidal marine habitats, and stream and river channels. Highway construction activities typically include in-water placement of fill in intertidal and subtidal areas, excavation of roadside drainage ditches, placement of culverts in stream channels, and construction of bridges over river channels. Shoreline stabilization structures are often used in coastal highway construction to modify hydraulic forces and control sediment movement and supply (Williams et al. 2003). Such structures may cause significant impacts to nearshore geomorphology, hydrology, and wave energy. Placement of "hard" armoring may alter the distribution and extent of existing habitats, for example where soft beach substrate is replaced by hardened substrates. A widely recognized impact of this is the permanent loss of fish spawning and shellfish habitat on upper intertidal beaches (Williams et al. 2003). Pile driving would be associated with multi-span bridge river crossings. Highways, bridges, and culverts can also result in the physical alteration of local habitats.

Highways could affect local hydrology via an increase in impervious surface area, subsequent alteration of shallow groundwater and surface water flow, and river- and stream-channel alteration by culvert or bridge structures (Forman et al. 2003).

Table 5. Vulnerabilities of Herring (*Clupea pallasi*) Populations to Typical Coastal Highway and Marine Transportation Facilities

	Highway Options				Marine Options			
Factors	Eggs	Larvae	Juvenile	Adults	Eggs	Larvae	Juvenile	Adults
Water Quality: PAH	⊕	⊕			⊕	⊕		
Water Quality: Other Contaminants	⊕	⊕			⊕	⊕		
Water Quality: Nutrients								
Water Quality: Salinity / Temperature								
Water Quality: Turbidity	⊕	⊕			⊕	⊕		
Habitat Alteration: Wave Energy					●			
Habitat Alteration: Shade / Light					⊕	⊕	⊕	⊕
Habitat Alteration: Beach Morphology	●				●			
Habitat Alteration: Substrate	●				●			
Habitat Alteration: Hydrology	⊕				⊕			
Disturbance				⊕		⊕	⊕	⊕
Predation	⊕			⊕	⊕			⊕
Prey		⊕				⊕	⊕	

● Yes / Very Likely
⊕ Maybe / Some Potential
blank cell No / Not Likely

Table 6. Vulnerabilities of Eulachon (*Thaleichthys pacificus*) Populations toTypical Coastal Highway and Marine Transportation Facilities

	Highway Options				Marine Options			
Factors	Eggs	Larvae	Juvenile	Adults	Eggs	Larvae	Juvenile	Adults
Water Quality: PAH	⊕			⊕		⊕		
Water Quality: Other Contaminants	⊕			⊕		⊕		
Water Quality: Nutrients								
Water Quality: Salinity / Temperature								
Water Quality: Turbidity (Sediment)	⊕							
Habitat Alteration: Wave Energy								
Habitat Alteration: Shade / Light								
Habitat Alteration: Channel Morphology	●			⊕				
Habitat Alteration: Substrate	●			⊕				
Habitat Alteration: Hydrology	⊕			⊕				
Disturbance				⊕				
Predation	⊕			⊕				⊕
Prey		⊕				⊕		

● Yes / Very Likely
⊕ Maybe / Some Potential
blank cell No / Not Likely.

Highway construction activities and structures that affect river or stream hydrology, channel morphology, or substrate composition where eulachon populations have historically spawned, may influence upstream migration and spawning success of adult eulachon (Table 6). Sediment resuspension from construction could smother or inhibit development spawned eulachon eggs. It is unclear from the literature how substantial changes in river bottom substrate may affect the long-term viability of eulachon spawning habitat. Highway construction can affect Pacific herring adults and eggs if construction activities along the shoreline directly displace or bury habitats where there has been historic spawn deposition (Table 5).

5.2.1.3 Disturbance

Noise and vibrations associated with pile-driving, blasting, and heavy machinery during construction could affect the distribution and behavior of adult herring and eulachon in documented shoreline and riverine spawning habitats, respectively (Tables 5 and 6). Activities associated with the maintenance, and operation of highways includes unnatural disturbances, such as noise, artificial light, and movement. However, it is unclear from the literature whether vehicle traffic and other human-associated activities at road crossings (bridges or culverts) and along shorelines would disrupt natural behaviors (e.g., avoidance or schooling) of adult eulachon and herring during spawning aggregations.

5.2.1.4 Alteration of Prey/Predator Populations

As previously noted, highways along marine shorelines can alter shoreline substrates due to in-water fill, which may affect primary production and the distribution and abundance of local invertebrate communities. This would have the potential for altering the production of prey taxa (e.g., copepods, invertebrate eggs, and diatoms) for larval herring and eulachon in shallow, nearshore habitats (Tables 5 and 6). However, McGurk et al. (1993) have suggested that Pacific herring stocks at low density (i.e., the Lynn Canal stock) are probably not limited by food but by other factors, such as incubation conditions (e.g., desiccation, extremes of temperature, predation).

It is currently unclear from the literature how eulachon and herring predators would be affected by construction and human use of highways along shorelines and at river crossings. Changing predation rates in marine nearshore habitats could affect eulachon and Pacific herring populations, especially during spawning (eggs and adult life history stages) (Tables 5 and 6).

5.2.2 Marine Traffic and Terminals

Most of the impacts associated with the proposed marine alternatives would be concentrated in shallow, nearshore marine habitats in the vicinity of ferry terminals. Therefore, herring and eulachon life-history stages that use nearshore marine habitats would be more likely to be affected by these activities.

5.2.2.1 Water Quality

Construction, maintenance, and operation of marine ferry terminal facilities are potential sources of contaminants to receiving marine waters. Marine activities present a risk of accidental fuel or sewage spills, which could result in disturbances to affected habitats and ecological communities. Although the frequency and amount of U.S. oil spills has decreased over the past 20 years, small spills (<100 gallons) still represent 92% of the total spill number (Etkin 2001). Unfortunately, little is known about the environmental impacts of diffuse, low-level oil pollution. Low-level discharge of treated sewage can elevate levels of contaminants, such as fecal coliform bacteria, dissolved and suspended solids, and metals. For example, marine vessels that use traditional systems to treat blackwater can discharge levels of contaminants such as free chlorine, fecal coliform, copper, and zinc in excess of water quality standards during stationary discharge (ADEC 2004). In general, contaminants that are associated with particulate matter and released into the water column can accumulate in sediments and bioaccumulate (concentration of persistent contaminants) in organisms (Newton et al. 1995). Placement of in-water fill, dredging, or construction of marine overwater structures can temporarily elevate turbidity levels.

Herring eggs and herring and eulachon larvae that are found in the vicinity of proposed marine ferry terminals have some potential to be exposed to low-level concentrations of contaminants associated with accidental spills or the discharge of treated sewage from the ferry terminal sanitary sewer treatment plant (Tables 5 and 6). Herring-egg development may also be directly affected by turbidity and sedimentation generated by ferry terminal construction and ferry propeller wash.

5.2.2.2 Habitat Loss / Alteration

Activities associated with construction of ferry terminals would cause the direct loss, modification, or replacement of intertidal and subtidal habitats. Terminal construction activities typically include dredging to provide and maintain adequate depth for vessels in navigation channels, slips, and berthing areas, as well as in-water fill to create breakwaters and jetties that dissipate wave energy and protect and stabilize navigation channels and harbor areas.

Typical marine terminal facilities and ferry service activities can indirectly result in the physical alteration of local habitats. These structures, as well as associated ferry activities, may cause chronic alteration to nearshore wave energy, light regimes, geomorphology, substrates, and hydrology, some of the most important factors controlling the development, distribution, and connectivity of nearshore habitats (Williams and Thom 2001). Chronic impacts on nearshore hydrological processes, including altered wave energy and current patterns, and obstruction of littoral drift and longshore sediment transport, may result from placement of structures below the ordinary high-water mark. Wakes from some high-speed ferries have a longer wave than conventional ships that may lead to substantial wave action in shallow nearshore areas (Parnell and Kofoed-Hansen 2001). This issue has not yet been quantitatively studied for the Alaska high-speed ferries, which are purported to have a shallower draft and smaller wakes than conventional craft. Additionally, operation of marine vessels commonly associated with overwater structures can cause sediment scouring that can have a deleterious effect on submerged vegetation and benthic communities (Nightingale and Simenstad 2001). Laboratory flume studies on the potential effects of ferry propeller wash on eelgrass from increased current velocities found that velocities above 100 cm/s caused significant sediment erosion and extensive damage to eelgrass rhizomes (Hart Crowser, Battelle, and Hartman Associates 1997). Shading from overwater structures may result in the loss of aquatic vegetation, which provides spawning substrate and a source of primary production that fuels local food webs (Nightingale and Simenstad 2001). For submerged aquatic plants such as eelgrass (*Zostera marina*) and kelp, shading reduces levels of photosynthetically active radiation (PAR) necessary for survival. Light is also a determining factor in fish migration, prey capture, and predator avoidance (Nightingale and Simenstad 2001). Blaxter (1985) suggests that herring feeding, movement, and schooling behavior is affected by light levels, with vertical migration of herring schools tracking the 1 lux (lx) isolume. Thus, overwater structures which substantially reduce light levels below this 1 lx could affect these behaviors. Breakwater structures can also influence local hydrology by changing the flow of water over adjacent substrates, causing scouring, changes in bathymetry and flushing rates, and alteration of sediment transport (Nightingale and Simenstad 2001).

Herring eggs present in shallow-water spawning habitats could be removed or buried during dredging activities (Table 5). In-water fill would displace or cover nearshore spawning habitat. Eulachon at any life-history stage are unlikely to be affected significantly by habitat alterations associated with ferry terminal construction activities (Table 6).

Marine ferry terminals have some potential to affect local hydrology and wave energy, which may affect flushing rates that affect herring egg development in known shallow-water spawning habitats (Table 5).

Ferry propeller wash and wakes may also increase wave action, displacing herring eggs from shallow shoreline habitats. Modification or replacement of natural substrates by ferry terminals would likely inhibit future spawning activities by herring in the disturbed areas (e.g., dredged basin). Depending on ambient light levels, shading from overwater structures may influence the distribution of vegetation (e.g., kelp or eelgrass) that may provide spawning substrates, and may affect adult, juvenile, and larval herring feeding behavior along nearshore habitats.

Because of the general lack of knowledge as to their dependence on marine nearshore habitats, it is not clear whether eulachon at any life-history stage would be affected by habitat alterations typically associated with marine ferry terminals (Table 6).

5.2.2.3 Disturbance

Activities associated with the construction, operation, and maintenance of ferry terminals include unnatural disturbances such as noise, artificial light, and movement. Noise associated with pile-driving operations during construction may affect the distribution and behavior of salmon and other fish and wildlife species (Feist et al. 1996). Pile driving can produce acoustic pressure waves that have been shown to cause mortalities in fish close to the pile as a result of the hemorrhaging and rupture of swim bladders, kidneys, and other internal organs (Hastings 2001).

Construction activities, artificial lighting, noise, vessel traffic, and other human-associated activities near ferry terminals may disrupt natural behaviors (e.g., avoidance or schooling) of larval, juvenile, and adult herring, especially near known shoreline spawning habitats (Table 5). It is not clear from the literature whether marine life history stages of eulachon would be affected by these disturbances (Table 6).

5.2.2.4 Alteration of Prey/Predator Populations

As previously noted, proposed marine ferry terminals have some potential to permanently disrupt nearshore marine habitat characteristics that affect primary production and the distribution and abundance of local invertebrate communities (Hass et al. 2002). As such, these disruptions (e.g., dredging, in-water fill) have the potential for altering the production of prey (e.g., copepods, invertebrate eggs, and diatoms) for local populations of larval and juvenile herring and eulachon larvae (Table 5 and 6). Prey abundance and capture rate may be reduced under shaded piers as compared with open-water areas for some fish species (Duffy-Anderson and Able 1999). As previously noted, however, McGurk et al. (1993) have suggested that Pacific herring stocks at low density are probably not limited by food but by other factors, such as incubation conditions.

It is currently unclear from the literature how eulachon and herring predators would be affected by construction and operation of marine terminals along shorelines. Changing predation rates in marine nearshore habitats could affect eulachon and Pacific herring populations, especially during spawning (eggs and adult life history stages) (Tables 5 and 6).

5.3 Cumulative Effects

This section briefly reviews evidence regarding possible cumulative effects of past human activities on Pacific herring and eulachon populations in Lynn Canal. The potential for cumulative effects to populations associated with project alternatives is covered in the EFH Assessment and the Indirect and Cumulative Effects Technical Report.

Cumulative effects are associated with an increasing number and size of direct and indirect impacts. Because human actions in upland, wetland, riparian, estuarine, and marine habitats may affect both adjacent areas and sites far removed from the immediate site of modification, impact responses may be linear or non-linear. The cumulative effect of many small modifications has the potential to produce interactive or synergistic impacts, rather than merely additive impacts, although this remains untested (Williams and Thom 2001).

As stated in section 3.1.3, Lynn Canal herring stocks are currently in a depressed state, with documented spawning areas reduced to a fraction of their historic extent and remnant spawning habitats now centered in Berners Bay. Various hypotheses, such as overfishing, increased predation, disease, habitat alteration or degradation (especially in Auke Bay), water pollution, and unfavorable oceanographic conditions have been put forward as to why Lynn Canal herring stocks have declined, although none have been substantiated through careful scientific analysis.

In the absence of a more detailed retrospective analysis of herring data, it is likely that some combination of the previously stated factors have cumulatively contributed to the decline of Lynn Canal herring stocks. This conclusion is supported by previous assessments of herring stock collapses worldwide, which found that in most cases multiple factors acted in combination with others and single-factor causes were rare. Overfishing may have played a role in the initial decline of Lynn Canal herring stocks; however, stocks have not rebounded despite a complete reduction in fishing pressure, suggesting that other stresses remain. Because herring are vulnerable to spawning ground disruptions, the declining use of Auke Bay spawning areas by Lynn Canal herring has often been circumstantially linked with cumulative increases in shoreline development and human use since the 1980s (personal communication, K. Monagle, ADF&G; S. Walker, NMFS). Predation pressure by sea lions and seals may be holding Lynn Canal herring stocks at low biomass because of increased natural mortality associated with smaller herring school sizes. Finally, disease (e.g., VEN) and climate change have also been widely considered as possible factors in the decline, or limited recovery, of Lynn Canal herring stocks.

As stated in section 3.2.3, there is currently no reliable index of eulachon run health in Lynn Canal, making it difficult to assess past cumulative effects on these populations. However, previous researchers have implicated a variety of factors in the cumulative decline of eulachon populations throughout their entire geographic range. Long-term declines in specific populations (e.g., Columbia River) have often been attributed to river-based industrial contamination or local habitat alterations, such as dredging, forest practices, and log booms that affect eulachon spawning habitat. More widespread population declines may be attributed to marine fisheries harvests and bycatch, as well as ocean changes that affect eulachon prey or predator distribution and abundance.

6.0 Summary and Conclusions

Pacific herring and eulachon are ecologically and commercially important forage-fish species. They are prey species for a variety of fish, mammals, and birds, and are also harvested for commercial, personal, and subsistence use.

The Pacific herring stock in Lynn Canal has been in a state of decline since the 1970s, with an estimated reduction in adult biomass from 4000 to 1000 tons. Similarly, the linear extent of Lynn Canal shoreline with documented herring spawn has declined (3 miles in 2003 compared to an average of 12 miles from 1953-1981), with a notable shift in the center of spawning activity. The Lynn Canal herring fishery has been closed for over 20 years without recovery to previous levels. This delayed recovery suggests that factors other than harvesting are now influencing the population levels and may be inhibiting recovery to previous levels.

While formal eulachon stock assessments have not been conducted in Southeast Alaska, anecdotal evidence and trends from other areas suggest long-term declines in run biomass of this species as well. Various hypotheses for these declines have been posited, such as overharvest, increased predator populations, disease, habitat alteration or degradation, water pollution, and unfavorable oceanographic conditions, however none have been substantiated through careful scientific analysis.

There is concern that proposed Juneau Access Improvement Project alternatives have the potential to affect Pacific herring and eulachon populations in Lynn Canal. To address this concern, a systematic approach based on U.S. EPA risk assessment guidelines was undertaken to characterize the potential exposure and effects of activities associated with typical highway and marine transportation facilities. Life-history information was integrated into a conceptual model to clarify the distribution and use of various habitats by species' life-history stage, and identify those stages most vulnerable to project activities. Stressors that have impacted herring and eulachon at the organism and population levels in other systems were then identified from the literature and evaluated for their relevance to the project. These stressors include fishing/harvest, impaired water quality, habitat alteration, human disturbance, disease, increased predation, decreased prey resources, ocean climate, and stochastic processes. Population level effects have most often been attributed to the result of changes in multiple stressors acting in combination with one another (Pearson et al. 1999).

In general, human activities that could affect the quality or spatial extent of documented spawning habitats along shorelines or lower river channels represent the highest likelihood for ecological impacts to Lynn Canal herring and eulachon populations. Both Pacific herring and eulachon are highly dispersed in marine waters throughout most of their life history, but congregate in spawning habitats during a short period of time in the spring. This makes spawning adults and early life history stages vulnerable to activities that impact shorelines, nearshore areas, and lower-river reaches.

Most of our conclusions focus on alteration of spawning habitat, in part because impacts readily translate into estimates of lost reproductive potential. In fact, the biomass of mature herring in Lynn Canal is currently derived solely from spring surveys of spawn deposition along shorelines. Therefore, activities that directly impact spawning habitats can most easily be predicted and avoided. Few other effects are as easy to translate into population-level effects. For example, indirect effects such as water quality contamination or human disturbance are more difficult to estimate given the uncertainties of runoff composition, concentration, and mixing rates, although they could have negative effects if they occur at the wrong time.

Data that would be useful to a more detailed analyisis include the following:

1. Current data on Lynn Canal herring distributions for comparison with the research of Carlson (1980). For example, the location of overwintering areas and pre-spawning aggregations may have changed since the 1970s, shifting closer to the center of spawning activity in Berners Bay.
2. Current data on eulachon run size, stock structure, and marine life history. In particular, there is little information on the marine distribution of larval, juvenile, and adult eulachon in Lynn Canal during the winter. There is some indication that larval eulachon densities may be high in some bays during the winter (personal communication, M Sigler, NMFS; Dave Harris, ADF&G).

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