# Susitna-Watana Hydroelectric Project
# (FERC No. 14241)

# Eulachon White Paper

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

HDR Alaska, Inc.

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# TABLE OF CONTENTS



# LIST OF TABLES

# APPENDICES

# LIST OF ACRONYMS AND SCIENTIFIC LABELS

| Abbreviation | Definition |
|---|---|
| μmhos | micromhos |
| ADF&G | Alaska Department of Fish and Game |
| AEA | Alaska Energy Authority |
| APA | Alaska Power Authority |
| APA Project | APA Susitna Hydroelectric Project |
| cfs | cubic feet per second |
| CIBW | Cook Inlet beluga whales |
| cm | centimeter |
| CPUE | catch per unit effort |
| ESA | Endangered Species Act |
| FERC | Federal Energy Regulatory Commission |
| FR | Federal Register |
| ft/s | feet per second |
| ILP | Integrated Licensing Process |
| km | kilometer |
| m | meter |
| $m^3$ | cubic meter |
| mg/L | milligrams per liter |
| mm | millimeter |
| m/s | meters per second |
| NEPA | National Environmental Policy Act |
| NMFS | National Marine Fisheries Service |
| ODFW | Oregon Department of Fish and Game |
| Project | Susitna-Watana Hydroelectric Project |
| RM | river mile |
| WDFW | Washington Department of Fish and Wildlife |

# 1. INTRODUCTION

This white paper presents the results of efforts to address portions of two objectives of the 2012 Cook Inlet Beluga Whale Study related to eulachon. Those objectives include:

- Summarize life history, run timing, abundance, distribution, and habitat of beluga whale prey species (eulachon and adult Chinook, chum, coho, and sockeye salmon) in the Susitna River; and

- Evaluate life history, run timing, abundance, distribution, and habitat of beluga whale prey species (eulachon and adult Chinook, chum, coho, and sockeye salmon) in other Cook Inlet tributaries used by beluga whales

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project) using the Integrated Licensing Process (ILP). The Project is located on the Susitna River, an approximately 300-mile-long river in Southcentral Alaska. The Project's dam site would be located at river mile (RM) 184.

This effort provided data to inform the 2013–2014 licensing study program, Exhibit E of the License Application, and FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

# 2. DESCRIPTION

Eulachon (*Thaleicthys pacificus*) are small (less than 250 millimeters [mm] fork length and weigh 40 to 60 grams) forage fish from the family Osmeridae. They are distributed along the west coast of North America from the Pribilof Islands and the eastern Bering Sea in Alaska southward to the Klamath River in California (Scott and Crossman 1973). At least 35 rivers in Alaska have spawning runs of eulachon (Moffitt et al. 2002), with the Nushagak River being the northernmost river known to support a spawning population (Mecklenberg et al. 2002).

Eulachon, also known as hooligan or candlefish, are anadromous, meaning adults migrate from the ocean to spawn in freshwater streams and rivers where their offspring hatch and migrate back to the ocean to forage until maturity. Although they spend greater than 90 percent of their lives at sea (Hay and McCarter 2000), available information on eulachon in the ocean environment is sparse (Stables et al. 2005). In most cases, eulachon spawn once, and then die; however, Scott and Crossman (1973) found evidence of repeat spawning.

Eulachon are sexually dimorphic with males typically being of greater length and having longer and wider ventral fins than females (Spangler et al. 2003; Cambria Gordon 2006). Males have tubercles on the body, head, fins, and particularly the lateral lines (McPhail and Lindsey 1970; Spangler et al. 2003), and have greater muscle mass along the lateral line than females (Spangler et al. 2003). In the Twentymile River, Alaska, females have been observed to retain their teeth to a greater degree than males (Spangler 2002).

Because of their abundance in the Susitna River, eulachon were investigated in association with the Alaska Power Authority's (APA) early 1980s hydroelectric efforts on the Susitna River (APA Project). With the reevaluation of the Project, eulachon are again being studied because of their importance as a prey species for Cook Inlet beluga whales (CIBW). The purposes of this paper are to summarize the information available regarding eulachon life cycles across their range and examine the information regarding eulachon in glacial systems, focusing on the Susitna River. This synthesis will also aid in study planning and management decisions for the Project.

# 3. LIFE HISTORY

## 3.1. Larvae to Juveniles

Eulachon start and end their life cycle in fresh water. Newly hatched larvae are transparent, slender, and poor swimmers. Reported lengths ranged from approximately 4 to 8 mm (Parente and Snyder 1970; WDFW and ODFW 2001; Hay et al. 2002; Lewis et al. 2002). Because they are weak swimmers, larvae are rapidly carried downstream to estuarine portions of rivers and inlets within hours or days of hatching (Smith and Saalfeld 1955; Parente and Snyder 1970; Samis 1977; Howell 2001). Larval eulachon may remain in low salinity surface waters of estuaries for several weeks or longer (Hay and McCarter 2000), especially in inlets or fjords (McCarter and Hay 1999; 2003).

Both the short time eulachon larvae spend in fresh water and their small size when reaching salt water likely preclude their ability to imprint on a spawning river (McCarter and Hay 1999; Hay and McCarter 2000). However, eulachon larvae and juveniles may spend weeks to months in nearby estuarine environments where they grow significantly in size and may develop the capacity to imprint on large estuaries and eventually home to these areas as adults (McCarter and Hay 1999; Hay and McCarter 2000). From April to August, larval eulachon on the central British Columbia coast were estimated to grow to 30 to 35 mm in length (McCarter and Hay 1999; 2003). Large river estuaries, inlets, and fjords may therefore serve as the smallest stock structure unit for eulachon (McCarter and Hay 1999; 2003; Hay and McCarter 2000; Hay 2002; Hay and Beacham 2005).

Most eulachon larvae have been found in the top 15 m of the water column, with few found below 20 m (McCarter and Hay 1999; Hay and McCarter 2000). Robinson et al. (1968) determined that almost all eulachon larvae in the Strait of Georgia, off the Fraser River, were distributed in the top 6.5 m of the water column. Larval eulachon were usually located near the bottom during their downstream migration in the lower Columbia River (Smith and Saalfeld 1955; Howell et al. 2001), but were distributed throughout the water column in the Fraser River estuary (Levings 1980).

## 3.2. Juveniles to Adults

Eulachon that range from 30 to100 mm in length, exhibit schooling behavior, and have developed pigmentation and lateral scales are generally classified as juveniles (Hay and McCarter 2000). Once juvenile eulachon enter the ocean environment, they move from shallow nearshore areas to deeper areas over the continental shelf. Hay and McCarter (2000) reported that juveniles dispersed to open, marine waters within one year and perhaps within the first few months. Eulachon juveniles feed on zooplankton, eating chiefly crustaceans such as copepods, euphausiids, malacostracans, and cumaceans (76 FR 65324).

Little information is available about eulachon movements in nearshore marine areas and the open ocean because they are too small to occur in most fisheries and too large to occur in ichthyoplankton surveys (Hay and McCarter 2000). However, eulachon occur as bycatch in the ocean shrimp (*Pandalus jordani*) fishery, indicating that the distributions of these two species overlap (76 FR 65324). Barraclough (1964) sampled juvenile eulachon in the Strait of Georgia in winter and spring with midwater trawls and shrimp trawls and learned that at least some portion of first year Fraser River eulachon were present. Few eulachon were caught as bycatch in the late 1990s in the Strait of Georgia shrimp fishery (Hay et al. 1999); however, a larger mesh size is used in commercial shrimp trawls compared to the mesh size used by Barraclough (1964). Thus, although they may be present in coastal waters, juvenile eulachon have been difficult to detect without a directed effort.

Because of their high lipid content, juvenile and adult eulachon are a valuable prey item (Hay and Boutillier 1999). Several marine mammal species feed upon juveniles and adults, and spawning runs may be may be preyed upon by several bird, mammal, and fish species.

## 3.3. Adult Migration and Spawning

After spending several years at sea continuing to feed on crustaceans, eulachon return to the freshwater environment to spawn. Seasonal entry into spawning rivers appears related to water temperature and the occurrence of high tide (76 FR 65324). Eulachon are fundamentally semelparous, spawning once and then dying, although some individuals may survive to spawn twice. The frequency of iteroparity (multiple spawning) in various populations is not well understood (Hay and McCarter 2000; Lewis et al. 2002).

Hay and McCarter (2000) and Cambria Gordon (2006) found no clear latitudinal or other pattern in eulachon spawn timing. The temperature at which eulachon spawning runs commenced varied by geographic area; however, a clear pattern was not readily discernible (Spangler 2002). Eulachon spawned as early as January in rivers of the Copper River delta of Alaska (Moffitt et al. 2002), as late as May in northern California, and from January to April in various reaches of the Columbia River. In Southeast Alaska, spawning migrations can occur in April, with the Chilkat and Alsek rivers having occasional winter runs in January and February. Spawning migrations generally occur in May in Central and Western Alaska. Moody (2008) found that the analysis of spawn timing as a stock identifier in eulachon was complicated by observed variation in the duration of spawning from year to year, the presence of multiple spawning runs in some rivers, and observations of eulachon returning earlier in recent years in some systems relative to historical data.

Eulachon appear to use streams in the general area where they were spawned that have the best habitat conditions. Abundance in a particular stream can vary greatly from year to year depending on water conditions and overall ocean survival (Emmett and Brodeur 2000). Some streams can have two overlapping runs (ADF&G 2008).

Although timing and duration of eulachon spawning migrations in Alaska have been studied (ADF&G 1984; Spangler et al. (2003), information on the amount of time spent in fresh water by individual fish is sparse. Spangler et al. (2003) used radio telemetry to help characterize the spawning migration in the Twentymile River, and noted that individual fish spent relatively little time in fresh water, similar to rainbow smelt (4-10 days). Time spent in larger rivers is unknown.

Eulachon spawning rivers are typically slow moving because eulachon are weak swimmers that cannot travel through long stretches of high water velocity. Water velocity greater than 0.4 meters per second (m/s) may limit upstream movements (Lewis et al. 2002). Most spawning in the Susitna River occurred at water velocities of 0.15 to 0.75 m/s (Vincent-Lang and Queral 1984).

Spawning sites are in the lower elevations of most rivers, but in some rivers with long, flat deltas, spawning sites may be many miles upstream. Spawning in many rivers is often limited to areas of tidal influence (Lewis et al. 2002). Eulachon have been reported to go as far as 80 kilometers (km) up the Susitna River (Barrett et al. 1984; Vincent-Lang and Queral 1984), and once ascended more than 160 km in the Columbia River system.

Eulachon spawning rivers may be turbid or clear, but all are thought to have spring freshets, characteristic of rivers draining large snow packs or glaciers (Hay and McCarter 2000). In general, eulachon spawned at low water levels prior to spring freshets (Lewis et al. 2002), although runs in the Fraser River occurred at mid-levels of river discharge (Langer et al. 1977). Spawning sites varied among years within the same river system (Pedersen et al. 1995; Hay and McCarter 2000; Moffitt et al. 2002). Spawning substrates ranged from silt, sand, or gravel to cobble and detritus (Smith and Saalfeld 1955; Barrett et al. 1984; Vincent-Lang and Queral 1984), but sand was most common (Langer et al. 1977; Lewis et al. 2002).

Size of adult eulachon returning to spawn may vary among areas and years, with fish in Alaska generally being larger than fish from southern populations (Gustafson et al. 2010). The maximum known length for eulachon is 254 mm (Mecklenberg et al. 2002). Mean lengths of spawning eulachon from Alaska populations exceed 175 mm, whereas mean lengths from the Columbia River generally have been less than 175 mm (Gustafson et al. 2010). Males are usually slightly larger than females.

Although age determination of eulachon is difficult and uncertain, adult spawners have been reported to be 2 to 5 years-old (Smith and Saalfeld 1955; Hay and McCarter 2000; WDFW and ODFW 2001; Hay 2002; Hay et al. 2005; Schweigert et al. 2007). Based on seasonal fluctuations in barium and calcium concentrations in otoliths, Clarke et al. (2007) concluded that many eulachon have been aged incorrectly. Clarke et al. (2007) found only 3-year-old eulachon in the spawning populations in the Fraser and Kemano rivers, and found that the majority of fish for the Columbia, Skeena, and Copper rivers were primarily 2-, 3-, and 4-year-olds, respectively. These data suggest that southern populations spawn at an earlier age than northern populations.

Gustafson et al. (2010) reported that sex ratios of spawning fish varied, but males often outnumbered females. Spawning occurred at night (Hay and McCarter 2000; Lewis et al. 2002) or afternoon (Langer et al. 1977), at various depths depending on the river. The sexes must synchronize their activities closely, because eulachon sperm may remain viable for only a short time, perhaps only minutes (Hay and McCarter 2000). Lewis et al. (2002) described spawning behavior wherein males took positions either beside or on top of females. This description differs markedly from that in Langer et al. (1977), wherein males congregated upstream of groups of females and released milt simultaneously, and females laid eggs as the milt drifted over them.

## 3.4. Eggs and Incubation

Fecundity of spawning females may vary with respect to geography or among years, but no pattern is apparent. As expected, fecundity tends to increase with increasing fish length. Numerous studies found mean fecundity for "average size females" to be 25,000 to 35,000 eggs (Gustafson et al. 2010).

The reported size of eulachon eggs has varied slightly among studies. All reports indicated that the diameter of mature eggs ranged from approximately 0.75 to 1.02 mm (Parente and Snyder 1970; WDFW and ODFW 2001; Hay and McCarter 2000; Hay et al. 2002; HDR 2008). Mature eggs have an outer sticky membrane that turns inside out after being fertilized and remains attached to the egg by a short stalk, by which the egg adheres to particles of sand or other substrates (Hart and McHugh 1944: Smith and Saalfeld 1955: Hay and McCarter 2000). Eggs may drift downstream for a short time before adhering to the substrate. Even after adhering, water velocity may continue moving them downstream while they develop (Lewis et al. 2002).

Spangler (2002) and Spangler et al. (2003) noted that, in general, the incubation requirements for eulachon eggs appeared to increase with increasing latitude. Artificially spawned and incubated eulachon eggs from the Cowlitz River in Washington hatched in 21 to 25 days when reared between 6.5°C and 9.0ºC (Parente and Snyder 1970). Berry and Jacob (1998) reported the incubation period in the Kingcome River in British Columbia to be approximately 21 days. Flory (2008) indicated that the incubation period for eulachon in Southeast Alaska ranged from 4 to 6 weeks. In the Twentymile River in Southcentral Alaska, incubation was estimated to take 47 to 50 days (Spangler 2002; Spangler et al. 2003).

Egg survival rate may be variable depending on: 1) environmental conditions, 2) whether they are drifting or accumulating in areas of low velocity, and 3) whether they are exposed to salt water. Drifting eggs may survive at higher rates than stationary eggs (Lewis et al. 2002); however, salinity can be lethal (Farara 1996).

# 4. COOK INLET

Information on eulachon distribution and run timing is limited in Alaska and specifically in the Cook Inlet; however, eulachon are known to occur in at least nine streams within the Cook Inlet (Appendix A, Figure 1; Johnson and Blanche 2012).They may also be present near Kalagin Island, which may serve as a late-winter staging area for eulachon prior to migration to spawning streams in the Upper Cook Inlet (Figure 1 in Appendix A; NMFS 2010). Eulachon have also been harvested along the shorelines of Turnagain Arm and the Cook Inlet north of the Ninilchik River (NMFS 2010). Spangler et al. (2003) found eulachon in a few sampling events during 2000 and 2001 on Portage Creek and Placer River. Spangler et al. (2003) noted that prior to the 1964 earthquake; the Placer River run was much larger than that in Twentymile River. Eulachon were also found in streams in Trading Bay State Game Refuge; however, these runs have not been well documented (ADF&G 2012a).

## 4.1. Kenai River

Information on eulachon in the Kenai River is limited to presence data (ADF&G 1971; Johnson and Blanche 2012). Eulachon are present in the Kenai River between late April and late June.

## 4.2. Twentymile River

In 2000 and 2001, Spangler et al. (2003) used radio telemetry to examine the migratory behavior of spawning eulachon and also investigated larval outmigration. They found Twentymile River to have the longest spawning period of any river for which data are available. They also determined that males spent more time in freshwater than females. In 2000 the eulachon spawning migration started May 4 and continued through June 21, whereas in 2001 the migration began April 17 and continued through June 9.

Spangler et al. (2003) were unable to determine the uppermost extent of eulachon spawning in the Twentymile River through use of radio telemetry. Juvenile eulachon that would have been unable to swim upstream were located above the upstream-most documented location of adults. However, because few larvae were captured upstream, they concluded that most spawning grounds had been documented. Spangler et al. (2003) noted that radio telemetry was a useful tool to study eulachon migratory behavior, but should be combined with other methods, such as larval sampling, to determine upper limits of spawning.

Through examination of otoliths, Spangler et al. (2003) determined that age-2 males occurred more frequently during the early part of the run each year, whereas age-4 and age-5 males occurred during the latter part of the run. Age-3 fish dominated both years and were found throughout the runs. Age classes of females did not vary over time.

Outmigrating larvae were studied by Spangler et al. (2003) and HDR (2006; 2008). Although Spangler et al. (2003) found larvae over the course of 113 days (May 8 through August 28); densities were greatest from June 17 through July 20. Similarly, densities in 2006 were greatest from June 21 through July 12 (HDR 2008). In 2001, larvae were first observed 22 days after arrival of adults (Spangler et al. 2003). In 2006, larvae were initially most abundant at sampling sites near the mouth of Twentymile River; however, toward the end of the season they were more abundant at sites in Turnagain Arm (HDR 2006).

## 4.3. Susitna River

The most intensive studies on Cook Inlet eulachon occurred during the 1980s Susitna Hydroelectric evaluation performed by ADF&G under contract to APA (ADF&G 1983a; 1983b; Barrett et al. 1984; Vincent-Lang and Queral 1984). These studies assessed eulachon spawning, biology, and spawning habitat characteristics.

### 4.3.1. Spawning

During the 1980s Susitna Hydroelectric evaluation, ADF&G described two eulachon spawning runs in the Susitna River, with the second run being considerably larger than the first (Barrett et al. 1984). In 1982, the first spawning run occurred between May16 and May 30 and the second run occurred between June 1 and June 8. The run of eulachon was so dense that it appeared to create a visible surface wave (ADF&G 1983a). Even though the number of fish was much greater in the second run, the runs were similar in duration (Barrett et al. 1984).

In 1983, the first run occurred between May 10 and May 17 and the second run occurred between May 19 and June 6 (Barrett et al. 1984). The spawning run may actually have started earlier than recorded because migration had begun before sampling started (Vincent-Lang and Queral 1984). The highest catch per unit effort (CPUE) for both set nets and dip nets occurred on May 13 for the first run and on May 23 for the second run (Barrett et al. 1984). Vincent-Lang and Queral (1984) hypothesized that the differences in run timing between years was due to the surface water temperatures in the Susitna River. The river was warmer in 1983 and thus the spawning migration began earlier.

ADF&G (1983b) and Barrett et al (1984) conducted research to determine if eulachon spawning migrations were correlated with surface water temperature, mainstem Susitna River discharge, or Cook Inlet tidal height, because changes to surface water temperature and mainstem discharge were identified as potential Project impacts. In 1982, eulachon spawning runs occurred during increases in both mainstem discharge and surface water temperature (ADF&G 1983b). In 1983, however, no correlations were found between eulachon abundance, surface water temperature, or Cook Inlet tidal elevation, although the majority of eulachon movement into the Susitna River occurred at surface water temperatures between 6.0°C and 9.0°C (Barrett et al. 1984).

### 4.3.2. Biological Parameters

Morphological characteristics were collected from a subset of eulachon captured during 1982 and 1983 to aid in classifying the biological structure of the eulachon runs. Sex and spawning condition were determined by observations of milt or eggs (Barrett et al. 1984).

Males:

- Pre-spawners—bright coloration and thick milt
- Spawners—dark coloration and water milt
- Post-spawners—essentially void of milt

Females:

- Pre-spawners—eggs were not expelled freely
- Spawners—eggs were expelled freely
- Post-spawners—essentially void of eggs

Descriptive population information was summarized from 1983 catch data. Both the first and second runs of eulachon included 2-, 3-, and 4-year-old fish, with 3-year-olds dominating (92.6 percent of males and 97.2 percent of females in the first run; 92.3 percent of males and 92.1 percent of females in the second run; Barrett et al. 1984). For 3-year-olds, first-run males were longer and weighed more than second-run males (Table 4.3-1; Barrett et al. 1984). Age-3 females from the first run were slightly larger than their counterparts from the second run, but differences were not statistically significant.

**Table 4.3-1. Length and weight of pre-spawning condition eulachon captured by dip nets in the intertidal region from both runs during 1983 and segregated by age and sex[a]**

| Age | Sex | Run | Sample Size | Length (mm) | | Weight (g) | |
|---|---|---|---|---|---|---|---|
| | | | | Range | Mean | Range | Mean |
| 2 | M | 1 | 2 | 191—216 | 203 | 50.6—68.8 | 59.1 |
| 3 | M | 1 | 50 | 186—229 | 212 | 45.1—86.0 | 69.1 |
| 4 | M | 1 | 2 | 200—222 | 211 | 59.4—78.7 | 69.1 |
| 2 | F | 1 | 1 | 195 | 195 | 54.3 | 54.3 |
| 3 | F | 1 | 35 | 180—222 | 203 | 45.1—74.8 | 60.2 |
| 2 | M | 2 | 1 | 182 | 182 | 44.2 | 44.2 |
| 3 | M | 2 | 36 | 187—228 | 207 | 44.3—82.8 | 67.4 |
| 4 | M | 2 | 2 | 219—231 | 225 | 89.4—93.5 | 89.6 |
| 2 | F | 2 | 2 | 174—193 | 184 | 43.4—48.0 | 47.3 |
| 3 | F | 2 | 35 | 186—218 | 201 | 48.8—71.3 | 59.7 |
| 4 | F | 2 | 1 | 203 | 203 | 60.6 | 60.6 |

[a]Table adapted from Barrett et al. 1984.

Sex ratios differed depending on run and development stage (Table 4.3-2). Pre-spawning males outnumbered pre-spawning females in the first run, but pre-spawning females outnumbered males in the second run (Barrett et al. 1984). For spawners and post-spawners, males greatly outnumbered females. The high ratio of spawning males to females indicated that males matured earlier and stayed in spawning condition longer than females (Barrett et al. 1984).

**Table 4.3-2. Summarization of eulachon sex ratio by dip net and electrofishing efforts during 1983 between Susitna River mile 4.5 and 60.0[a]**

| Development Stage | First Run | | | Second Run | | |
|---|---|---|---|---|---|---|
| | n (males) | n (females) | M:F ratio | n (males) | n (females) | M:F ratio |
| Pre-spawners | 316 | 253 | 1.2:1 | 1,341 | 2,084 | 0.6:1 |
| Spawners | 1,320 | 70 | 18.9:1 | 3,730 | 788 | 4.7:1 |
| Post-spawners | 249 | 16 | 15.6:1 | 1,388 | 403 | 3.4:1 |

[a]Table adapted from Barrett et al. 1984.

### 4.3.3. Spawning Habitat Characteristics

Susitna River eulachon use a wide array of spawning habitats. Because eulachon are broadcast spawners their habitat requirements are not as constricted as other species (Morrow 1980). Sites were determined to be spawning sites by ADF&G (1983c) if the following criteria were met:

- Fish freely expelled eggs or milt

- Fish were in vigorous free swimming condition
- Twenty or more fish, which met the conditions above, were captured during a sampling event (ADF&G 1983c).

During 1983, 61 spawning sites were identified in the mainstem Susitna River (Barrett et al. 1984). The first run used 10 sites for spawning and the second run used 57 sites. All sites from the first run were used for the second run, with the majority (70 percent) of spawning occurring between river miles (RMs) 12 and 27.

Data from 1982 and 1983 indicated that eulachon preferred areas with moderate downstream velocities (0.3 to 3.0 ft/s) and were rarely found in low velocity waters (less than 0.3 ft/s), backwater, or eddies (ADF&G 1983a). Spawning depth averaged 130 cm and ranged from 40 to 170 cm (Appendix B, Table B-1; Vincent-Lang and Queral 1984). Eulachon spawned over a wide range of substrate types, but most spawning occurred near cutbanks and along riffles with loose sand and gravel. Because of the increased number of fish in the second run, spawning often occurred in less desirable habitat (i.e., deeper and higher velocity; Barrett et al. 1984). Eulachon appeared to utilize turbid water during both years because no spawning occurred in clear water streams, semi-placid main channel reaches, or sloughs (ADF&G 1983b).

In 1983, ADF&G measured water quality parameters at 20 spawning sites (Appendix B, Table B-2; Barrett et al. 1984). Water temperature ranged from 6.5°C to 10.8°C, pH ranged from 6.6 to 7.2, specific conductance ranged from 93 to 108 micromhos (µmhos), dissolved oxygen ranged from 5.9 to 11.3 milligrams per liter, and mainstem discharge ranged from 62,000 to 66,000 cubic feet per second.

The upstream extent of eulachon migration differed little between years (RM 49.5 in 1982 and RM 50 in 1983; ADF&G 1983a; Barrett et al. 1984). Most spawning occurred for both runs between RM 8.5 and the Yentna River confluence (RM 28; ADF&G 1983b). During 1982, eulachon were also observed in the Yentna River, upstream to Big Bend (approximately 8,000 meters upstream of the confluence with the Susitna River). Historically a few eulachon have been observed in the Yentna River up to the Skwentna River (approximately 23,000 meters upstream of the confluence with the Susitna River; ADF&G 1983a; see Appendix A, Figure 2). Recent anecdotal reports indicate possible eulachon presence in the Susitna River up to Talkeetna (RM 97); however, reliability of these reports is unknown, and they have not been validated by ADF&G.

# 5. IMPORTANCE

## 5.1. Subsistence and Personal Use Fisheries

Eulachon are highly important ceremonially, nutritionally, medicinally, and economically to First Nations people in British Columbia and Native American tribes in Alaska, northern California, and the Pacific Northwest. Many ethnographers and historians have stressed the cultural and nutritional importance of eulachon to the Tlingit of Southeast Alaska (Gustafson et al. 2010). Historically, Native tribes harvested eulachon for oil and food (Spangler et al. 2003). Fish and rendered oil were bartered with inland tribes, forming the “grease trails” of southeast

Alaska and British Columbia (Hart 1973; ADF&G 2008; Hay et al. 1997). Eulachon currently support important subsistence and personal use fisheries in Alaska (ADF&G 2008; Betts 1994).

Both subsistence and personal use fishing are allowed for eulachon in Cook Inlet. Eulachon personal use fisheries take place in salt water from April 1 through May 31, and in freshwater from April 1 through June 15. Eulachon may be harvested in the Upper Cook Inlet only by dip net (Rodrigues et al. 2006). Most subsistence and personal use harvest in the Upper Cook Inlet area occurs in the Twentymile River or in the estuary of Turnagain Arm.

Records from personal use and subsistence fisheries for eulachon are limited. Personal use harvest in Upper Cook Inlet ranged from 40,377 to 89,560 fish (2.2 to 5.0 tons) from 1993 through 2003 (Shields 2004). Historically, harvest averaged approximately 4 tons in the Twentymile River (Spangler et al. 2003). Actual personal use may be under-reported because of confusion with subsistence harvest (Shields 2004).

## 5.2. Commercial Fishery

Prior to 2005, the only documented commercial harvest of eulachon in the Upper Cook Inlet area occurred in 1978, 1980, 1998, and 1999. Gill nets were used prior to 1999, when reinterpretation of the harvest regulation allowed use of dip nets. With the change in gear, harvest increased from 18,900 pounds in 1998 to 100,000 pounds in 1999 (Table 5.2-1).

The commercial fishery was closed from 2000 to 2005, but was reinstituted beginning with the 2006 season. The fishery is conducted under the Cook Inlet Smelt Fishery Management Plan (Shields and Dupuis 2012), and is allowed in salt water only from May 1 through June 30, in the area of the Cook Inlet from the Chuitna River to the Little Susitna River. Legal gear is limited to hand-operated dip nets, with a maximum total harvest of 100 tons.

Eulachon harvest is generally limited by market demand and logistics of getting the catch to market (Shields and Dupuis 2012). The fishery quota was reached in 2011 for the first time since 1999 (Table 5.2-1). Most of the harvest is shipped to the west coast of the United States. The majority is sold as bait, with smaller amounts marketed for human consumption.

**Table 5.2-1. Commercial harvest of eulachon in the Upper Cook Inlet, 1978–2011**

| Year | Gear allowed | Harvest (lbs) |
|---|---|---|
| 1978 | Gill nets | 300 |
| 1980 | Gill nets | 4,000 |
| 1998 | Gill nets | 18,610 |
| 1999 | Dip nets | 100,000 |
| 2006 | Dip nets | 90,783 |
| 2007 | Dip nets | 125,044 |
| 2008 | Dip nets | 127,365 |
| 2009 | Dip nets | 78,258 |
| 2010 | Dip nets | 126,135 |
| 2011 | Dip nets | 201,570 |

## 5.3. Sport Fishery

The Upper Cook Inlet area and the Susitna River are open to sport fisheries for eulachon. Records prior to 1996 are limited, and many records combine eulachon and capelin *Mallotus villosus* as smelt. Most of the Susitna River sport fishery occurs between RM 10 and RM 30 (ADF&G 1983b). In 1982, an estimated 3,000 to 5,000 eulachon were harvested in the Susitna River sport fishery, but harvest decreased to between 500 and 2,000 eulachon in 1983 (Barrett et al. 1984).

Annual sport harvest in Southcentral Alaska from 2001 through 2010 averaged approximately 57,000 smelt (eulachon and capelin combined), ranging from approximately 17,000 to 94,000 fish. Harvest in the Susitna River during this period averaged about 4,500 smelt, ranging from 0 to more than 12,500 (ADF&G 2012; Table 5.3-1).

**Table 5.3-1. Sport harvest of smelt (number of eulachon and capelin combined) in Southcentral Alaska, including Upper Cook Inlet and the Susitna River, 2001–2010**

| Area | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
| Knik Arm | 1,574 | 0 | 1578 | 11 | 0 | 71 | 124 | 0 | 0 | 0 |
| Anchorage | 35,909 | 57,079 | 35,841 | 9,987 | 8,885 | 9,927 | 16,527 | 20,047 | 28,953 | 34,724 |
| Susitna River drainage | 10,056 | 3,298 | 5465 | 12,562 | 3,068 | 0 | 620 | 1,832 | 3,520 | 4,643 |
| West Cook Inlet drainages | 0 | 0 | 455 | 0 | 0 | 0 | 0 | 0 | 880 | 0 |
| Kenai Peninsula (freshwater) | 23,023 | 20,036 | 12,145 | 41,085 | 9,206 | 3,121 | 3,221 | 2,270 | 4,796 | 6,536 |
| Cook Inlet (saltwater) | 432 | 373 | 436 | 2,246 | 1,102 | 2,076 | 1,889 | 277 | 1,136 | 399 |
| **Total Cook Inlet Area Sport Fish Harvest by Year** | **70,994** | **80,786** | **55,920** | **65,891** | **22,261** | **15,195** | **22,381** | **24,426** | **39,258** | **46,302** |
| **Average of Cook Inlet Area Sport Fish Harvest by Year** | **11,832** | **13,464** | **9,320** | **10,982** | **3,710** | **2,533** | **3,730** | **4,071** | **6,548** | **7,717** |
| North Gulf Coast/Prince William Sound | 4,981 | 10,381 | 2,744 | 1,462 | 156 | 40 | 269 | 2305 | 15 | 39,425 |
| Kodiak | 45 | 0 | 0 | 0 | 98 | 0 | 0 | 0 | 0 | 178 |
| Alaska Peninsula-Aleutian Islands | 2,940 | 3,227 | 8,746 | 842 | 2,488 | 1,653 | 3,336 | 4,496 | 9,254 | 324 |
| Kvichak River drainage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nushagak, Wood River, and Togiak | 1,124 | 40 | 3,309 | 135 | 2,178 | 175 | 434 | 859 | 10,038 | 8,078 |

Source: ADF&G 2012b

## 5.4. Biological Importance

The high lipid content of eulachon (up to 21 percent) makes them an important prey species in the natural environment (Payne et al. 1999). Predators include a variety of fish (e.g., spiny dogfish shark [*Squalus acanthias*], Pacific salmon, Pacific halibut [*Hippoglossus stenolepis*], Pacific cod [*Gadus macrocephalus*]), birds (e.g., cormorants, gulls, eagles), marine mammals (e.g., beluga whales, killer whales [*Orcinus orca*], and harbor seals [*Phoca vitulina*]), brown bears (*Ursus arctos*), and wolves (Scott and Crossman 1973; Willson et al. 2006). In Cook Inlet, CIBWs and harbor seals (*Phoca vitulina*) are the most frequently documented eulachon predators (NMFS 2008; Willson et al. 2006).

Harbor seals in Alaska are not classified as strategic or depleted stocks and are not listed under the Endangered Species Act (ESA; Allen and Angliss 2011). The most recent population estimate for the Cook Inlet/Shelikof Strait harbor seal stock is 22,900 (Allen and Angliss 2011). Harbor seals are distributed throughout Cook Inlet, with the highest concentrations being in lower Cook Inlet. However, sightings of harbor seals in the upper inlet have been increasing over the past few years. The most recent aerial survey documented approximately 1,750 harbor seals in the Susitna River delta (Shelden et al. 2011).

CIBWs reside in Cook Inlet year-round and have been documented spending significant portions of time in Upper Cook Inlet (Funk et al. 2005; NMFS 2008; Allen and Angliss 2011). The CIBW was listed as a federally protected endangered species under the ESA in October 2008 (73 FR 62919). The current CIBW abundance estimate is 284 whales (Hobbs et al. 2011). In April 2011, the NMFS published a final rule designating critical habitat for the CIBW (76 FR 20180). The NMFS identified five primary constituent elements essential to the conservation of CIBWs, one of which was the availability of prey species, including eulachon. CIBWs use the Susitna River delta throughout the majority of the open water season (late April through September); therefore, occurrence in spring coincides with spawning migrations of eulachon and Pacific salmon (NMFS 2008).

# 6. NEED FOR ADDITIONAL DATA

Given the importance of eulachon to CIBWs and to personal use and commercial fisheries, the historic information on eulachon needs to be updated and expanded upon from the 1980s studies in the Susitna River. Information on timing and duration of the eulachon migration, location and number of spawning sites, spawning site characteristics, and population characteristics are needed to gain a comprehensive understanding of eulachon in the Susitna River, and serve as a baseline to evaluate the potential impacts of future actions. Changes in eulachon run timing and duration, or changes in abundance could change the availability of eulachon to CIBWs, and effect CIBW foraging success. Limited data from the Upper Cook Inlet Eulachon Commercial Fishery indicate that the eulachon may actually be older and larger than in the 1980s (Shields and Dupuis 2012). Therefore, collection of age, length, and weight data is needed to establish baseline information on population characteristics. Genetic samples would provide a baseline to assist in determining eulachon stock structure in Cook Inlet.

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# APPENDIX A. FIGURES

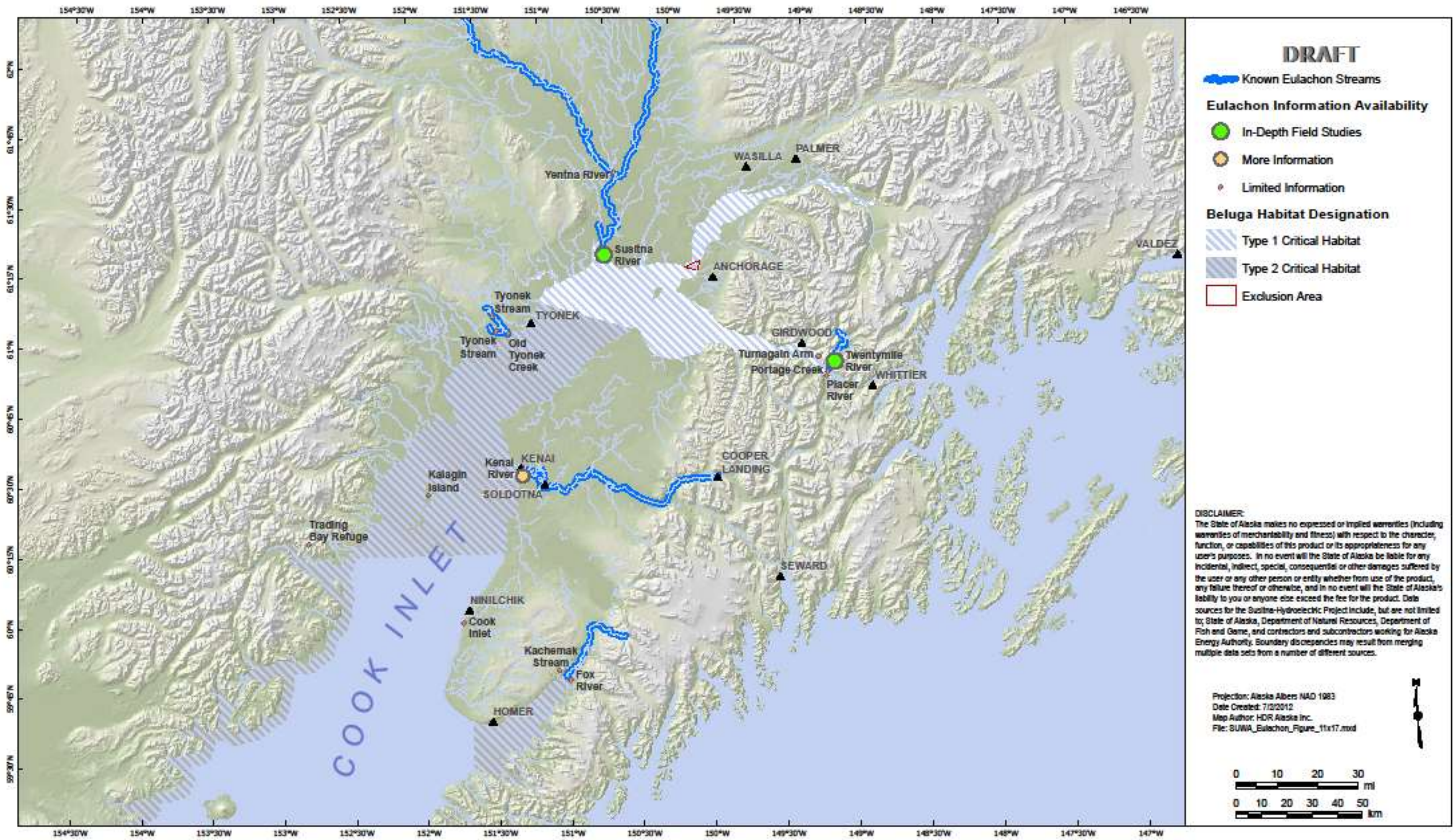


**Figure 1. Eulachon presence in Cook Inlet.**

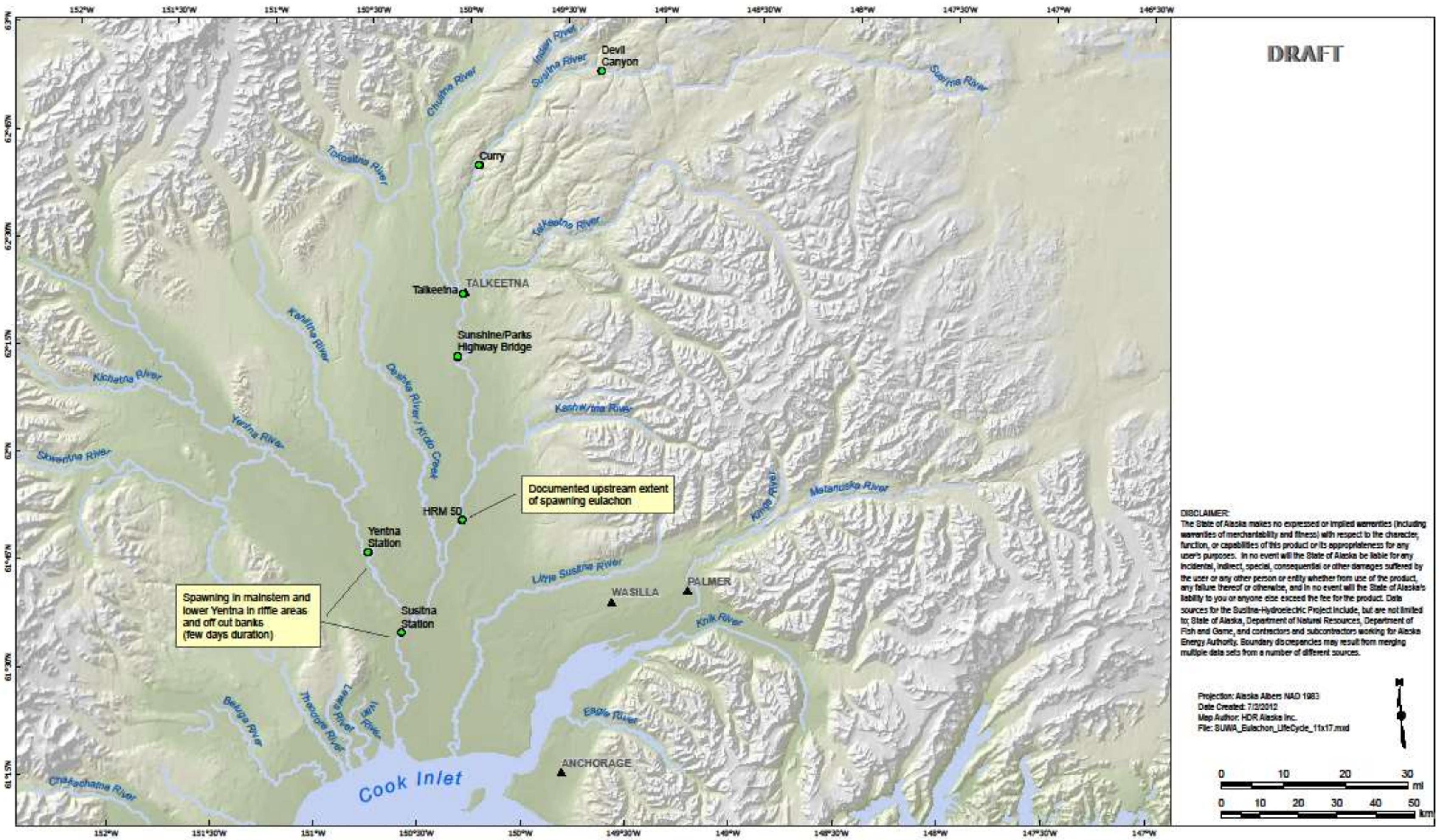


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**Figure 2. Eulachon presence in Susitna River.**

SUSITNA WATANA HYDROELECTRIC PROJECT

# APPENDIX B. SPAWNING HABITAT CHARACTERISTICS

**Table B-1 Spawning habitat characteristics in the Susitna River collected during 1983[a]**

| Date | RM | Water Depth (cm) | Water Velocity (ft/s) | Substrate Type | General Habitat Notes |
|---|---|---|---|---|---|
| 5/15 | 12.5 | 130 | 1.0 | 100% silty sand | Cutbank |
| 5/15 | 13.8 | 140 | 1.5 | 100% silty sand | |
| 5/17 | 23.0 | 170 | 2.0 | 75% gravel, 25% sand | |
| 5/20 | 9.8 | 100 | 1.5 | 100% silty sand | |
| 5/20 | 12.5 | 130 | 1.0 | 100% silty sand | Cutbank |
| 5/20 | 18.2 | 100 | 1.0 | 90% sand, 10% gravel | |
| 5/21 | 15.0 | 130 | 1.5 | 60% sand, 40% gravel | |
| 5/21 | 25.5 | 120 | 2.0 | 100% silty sand | Cutbank |
| 5/22 | 25.5 | 120 | 2.0 | 100% silty sand | Cutbank |
| 5/22 | 27.1 | 130 | 1.5 | 100% silty sand | Cutbank |
| 5/22 | 27.3 | 110 | 1.0 | 100% silty sand | Cutbank |
| 5/22 | 27.7 | 150 | - | 100% silty sand | Back eddy, cutbank |
| 5/23 | 9.0 | 110 | 1.0 | 100% silty sand | |
| 5/23 | 9.7 | 100 | 0.5 | 100% sand and gravel mix | Cutbank |
| 5/23 | 21.4 | 160 | 1.0 | 100% silty sand | Beach |
| 5/23 | 22.1 | - | - | - | |
| 5/23 | 23.0 | 170 | 2.0 | 75% gravel, 25% sand | |
| 5/24 | 12.5 | - | - | 100% silty sand | Cutbank |
| 5/24 | 13.1 | 80 | 2.0 | 100% silty sand | Cutbank |
| 5/24 | 13.3 | 110 | 1.5 | 100% silty sand | Cutbank |
| 5/24 | 13.4 | 120 | 1.5 | 100% silty sand | |
| 5/24 | 13.8 | - | - | 100% sand | |
| 5/24 | 13.8 | 130 | 1.0 | 100% silt | Gradual slope |
| 5/24 | 14.7 | 40 | 3.0 | 100% sand and gravel mix | Gradual slope |
| 5/24 | 14.9 | - | - | 100% silty sand | |
| 5/24 | 15.0 | - | - | 100% sand and gravel mix | |
| 5/24 | 15.5 | 120 | 2.0 | 100% silty sand | Cutbank |
| 5/24 | 15.5 | 130 | 3.0 | 100% silty sand | Cutbank |
| 5/24 | 15.7 | 100 | - | 100% silty sand | Back eddy |
| 5/24 | 16.2 | - | - | 100% silty sand | Beach |
| 5/24 | 16.5 | 130 | 1.0 | 100% silty sand | |

| Date | RM | Water Depth (cm) | Water Velocity (ft/s) | Substrate Type | General Habitat Notes |
|---|---|---|---|---|---|
| 5/24 | 17.1 | 130 | - | 100% silty sand | |
| 5/24 | 17.2 | 100 | 1.5 | 100% silty sand | |
| 5/24 | 17.7 | 150 | 2.0 | 100% silty sand | |
| 5/24 | 18.2 | 100 | 1.0 | 90% sand, 10% gravel | |
| 5/24 | 18.7 | 130 | 1.0 | 75% gravel, 25% sand | |
| 5/24 | 19.3 | 140 | - | 100% silty sand | Back eddy |
| 5/24 | 19.8 | 100 | 3.0 | 100% silty sand | Cutbank |
| 5/24 | 19.8 | 80 | 1.5 | 100% silty sand | |
| 5/24 | 21.3 | 80 | 2.0 | 100% silty sand | |
| 5/24 | 22.5 | 120 | 4.0 | 100% silt | Cutbank |
| 5/24 | 23.7 | 100 | - | 100% sand | Back eddy, cutbank |
| 5/24 | 24.8 | 90 | 1.5 | 50% sand, 50% gravel | |
| 5/25 | 6.1 | - | - | 100% silty sand | |
| 5/25 | 9.0 | 120 | 1.0 | - | |
| 5/25 | 9.8 | - | - | 100% silt and gravel mix | |
| 5/25 | 11.7 | 90 | 2.0 | 100% silt and gravel mix | Cutbank |
| 5/25 | 14.3 | 150 | 2.5 | 100% silty sand | Cutbank |
| 5/25 | 17.1 | - | - | 100% silty sand | Cutbank |
| 5/25 | 19.0 | 140 | 3.0 | 100% silty sand | Gradual slope |
| 5/25 | 22.0 | 80 | 2.0 | 100% sand | Gradual slope |
| 5/25 | 24.3 | 90 | 1.5 | 100% silty sand | Gradual slope |
| 5/25 | 27.8 | 70 | 1.5 | 100% silty sand | |
| 5/25 | 29.6 | 70 | 1.5 | 100% silty sand | Gradual slope |
| 5/25 | 32.0 | 100 | 2.0 | 100% silty sand | |
| 5/25 | 34.0 | 80 | - | 98% silty sand, 2% organics | Back eddy |
| 5/25 | 36.0 | 70 | 1.5 | 100% silt and gravel mix | |
| 5/25 | 38.2 | 70 | 1.5 | 50% sand, 50% gravel | |
| 5/25 | 41.6 | 80 | 3.5 | 100% silty sand | |
| 5/25 | 44.0 | 70 | 3.5 | 50% sand, 50% gravel | |
| 5/25 | 44.9 | 80 | 2.0 | 50% sand, 50% gravel | |
| 5/25 | 47.0 | 60 | 1.5 | 50% sand, 50% gravel | |
| 5/25 | 49.2 | 40 | 2.0 | 50% sand, 50% gravel | |

| Date | RM | Water Depth (cm) | Water Velocity (ft/s) | Substrate Type | General Habitat Notes |
|---|---|---|---|---|---|
| 5/26 | 4.5 | - | - | 100% silty sand | Gradual slope |
| 5/26 | 12.0 | 80 | 1.5 | 100% silty sand | Gradual slope |
| 5/26 | 25.5 | - | - | 100% sand and gravel mix | |
| 5/27 | 41.5 | 90 | 3.5 | 100% silty sand | |
| 5/27 | 41.7 | 110 | 1.5 | 100% sand and gravel mix | Cutbank |
| 5/27 | 50.5 | 90 | 0.5 | 100% silty sand | |
| 5/28 | 26.2 | - | - | - | |
| 5/29 | 27.5 | - | - | 100% silty sand | |
| 5/30 | 25.5 | - | - | 100% silty sand | Cutbank |
| 5/31 | 4.5 | - | - | 100% silty sand | Gradual slope |
| 5/31 | 6.4 | - | - | 100% silty sand | |
| 5/31 | 12.5 | - | - | 100% silty sand | Cutbank |

[a] Table adapted from Vincent-Lang and Queral 1984.

**Table B-2 Water quality variables collected at selected eulachon spawning habitats in 1983[a]**

| Site | RM | Date | Water Temperature (°C) | pH | Specific Conductance (µmhos) | Dissolved Oxygen (mg/l) | Mainstem Discharge (cfs) |
|---|---|---|---|---|---|---|---|
| 1 | 20.0 | 5/23/83 | 8.1 | 6.6 | 95 | 10.3 | 66,000 |
| 2 | 12.8 | 5/24/83 | 6.5 | 6.8 | 93 | 6.4 | 62,000 |
| 3 | 13.8 | 5/24/83 | 6.7 | 6.9 | 93 | 8.1 | 64,000 |
| 4 | 15.0 | 5/24/83 | 6.5 | 6.9 | 93 | 8.6 | 64,000 |
| 5 | 15.0 | 5/24/83 | 7.5 | 6.8 | 94 | 8.7 | 64,000 |
| 6 | 16.2 | 5/24/83 | 7.8 | 6.9 | 94 | 8.3 | 64,000 |
| 7 | 18.1 | 5/24/83 | 7.2 | 6.9 | 94 | 7.3 | 64,000 |
| 8 | 19.5 | 5/24/83 | 8.6 | 6.9 | 96 | 6.1 | 64,000 |
| 9 | 21.5 | 5/24/83 | 9.3 | 6.9 | 99 | 6.1 | 64,000 |
| 10 | 23.0 | 5/24/83 | 8.1 | 6.8 | 95 | 8.9 | 64,000 |
| 11 | 20.5 | 5/25/83 | 10.8 | 7.2 | 98 | 10.6 | 62,000 |
| 12 | 22.8 | 5/25/83 | 9.3 | 7.0 | 99 | 10.3 | 62,000 |
| 13 | 23.1 | 5/25/83 | 7.8 | 7.0 | 95 | 10.3 | 62,000 |
| 14 | 24.9 | 5/25/83 | 9.8 | 7.0 | 101 | 9.4 | 62,000 |
| 15 | 26.2 | 5/25/83 | 8.0 | 6.7 | 102 | 5.9 | 62,000 |
| 16 | 26.5 | 5/25/83 | 9.5 | 6.8 | 102 | 6.5 | 62,000 |
| 17 | 28.0 | 5/26/83 | 8.6 | 7.2 | 103 | 11.3 | 64,000 |
| 18 | 30.1 | 5/26/83 | 8.6 | 7.2 | 103 | 10.8 | 64,000 |
| 19 | 33.4 | 5/26/83 | 9.1 | 6.8 | 108 | 6.2 | 64,000 |
| 20 | 36.5 | 5/26/83 | 8.8 | 7.1 | 103 | 10.1 | 64,000 |

[a]Table adapted from Barrett et al. 1984.