

**WINTER  
FRESHWATER FISH HABITAT  
BASELINE REPORT**

**CHUITNA COAL PROJECT**

January 2009



Prepared for:

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## ACRONYMS AND ABBREVIATIONS

ANOVA.....	analysis of variance
CPUE .....	catch per unit effort
°C .....	degrees Celsius
cm .....	centimeter
DVD.....	digital video disk
FL.....	fork length
km .....	kilometer
LGL .....	LGL Environmental Research Associates
m .....	meter
ml .....	milliliter
mm .....	millimeter
nm .....	nanometer
NMT .....	Northwest Marine Technologies
OASIS .....	OASIS Environmental, Inc.
TL.....	total length
VIE .....	Visual Implant Elastomer
y.o .....	year-old

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## EXECUTIVE SUMMARY

PacRim Coal, LP has proposed to develop a surface coal mine on the northwest side of Cook Inlet known as the Chuitna Coal Project (Figure 1-1). OASIS Environmental, Inc. (OASIS) was contracted to gather baseline freshwater fisheries information and implemented a Freshwater Aquatic Biology Program in 2006 (OASIS 2007, 2008). This report adds to the knowledge base of the previous two reports and discusses juvenile fish use of winter habitat. The objective of the winter program was:

Determine the location, longitudinal movements (upstream/downstream) and habitat use of overwintering juvenile fish (emphasis on coho salmon (*Oncorynchus kisutch*) and Dolly Varden (*Salvelinus malma*)) within randomly selected segments of stream 2003 in the mine area during the winter of 2007/2008.

This was accomplished through a mark and recapture study, augmented by the use of an underwater video camera. Beginning in September 2007 and ending in early October 2007, a total of 2,032 fish (juvenile coho salmon  $n=1,907$  and small resident Dolly Varden  $n=125$ ) was captured in randomly selected segments of stream 2003 and marked with Visual Implant Elastomer (VIE) tags. Recapture minnow trap sites were chosen within stream 2003 which allowed OASIS to detect the movement of marked fish between and among stream segments. Minnow trap sites were also maintained at the mouths of streams 2002, 2003, and 2004 as a check for fish movement between Chuitna tributaries. Severe winter weather conditions prevented recapture at all recapture locations in October, November and December, 2007. Coverage of all designated trapping locations was completed in January, February, March, April and May 2008. An underwater video camera was deployed in January, February, March and April, 2008, and provided a means of detecting the presence or absence of fish in areas where minnow trapping was not possible, i.e. shallow riffles and high velocity runs.

Marked fish were recaptured during every sampling month with the highest number of recaptures occurring in January, 2008 ( $n=32$ ) and the lowest in the months of March ( $n=2$ ), and May ( $n=2$ ), 2008. Differences in juvenile coho salmon CPUE (sample size for Dolly Varden was too small for this analysis) were tested using linear regression and analysis of variance (ANOVA) at 95% confidence intervals. Coho CPUE decreased over time with significantly fewer fish captured in April and May as compared to January.

To delineate patterns of habitat use, three broad habitat categories were assigned to recapture sites: small channel (1-2 m channel width), large channel (3-4 m channel width), and beaver pond (main channel impoundments caused by beaver dams). Most fish were recaptured in large channel habitat ( $n=47$ ), followed by small channel habitat ( $n=34$ ), and beaver ponds ( $n=7$ ). Overall CPUE was higher in large channel habitat but with weak significance ( $p=.05097$ ). For the most part, tagged fish remained in the same habitat category and location in which they were originally tagged and remained there throughout the winter.

The majority of fish (81% of the total recaptures) were recaptured at their original tagging site (n=71). The longitudinal distance fish traveled from the site of tagging to the site of recapture was tested for significance using a t-test. Among recaptured fish that moved, upstream movement (n=8) was as common as downstream movement (n=8). Movement direction by species was 100% downstream for Dolly Varden and 33% downstream for juvenile coho salmon. However, a test for significance ( $\alpha=0.05$ ), using a two-sided t-test revealed that the average upstream and downstream movement of both Dolly Varden and juvenile coho salmon was not significantly different than zero. High variability in movement patterns indicated some fish were moving but, overall, most fish remained in close proximity to their original capture and tagging site, and remained in this location throughout the winter.

Underwater camera surveys collected under-ice images of juvenile coho salmon in three identified habitat types (riffle, run, and pool) in stream 2003, including under-ice images in riffle habitat too shallow to set minnow traps. The ability to use the camera in these conditions met a primary objective of the sampling method. The efficacy of using underwater video cameras during winter is limited by effects of cold on batteries, light penetration under water and difficulties obtaining useful data on fish (e.g., species ID, presence of tags, length, and relative condition).

Based on the results of winter sampling OASIS concludes that juvenile coho salmon and small resident Dolly Varden utilize habitat in Chuitna tributary stream 2003 during fall (September-October) and throughout the winter from freeze-up (November) until break-up (May). Though there is some movement of these fish during the winter, the majority of recaptured fish did not significantly move either upstream or downstream from their original capture and tagging location. Juvenile coho salmon were observed wintering in large channel habitat and relied less on beaver dammed pools than has been documented in other studies conducted in more southerly portions of their range.

## 1. INTRODUCTION

PacRim Coal, LP has proposed to develop a surface coal mine and associated facilities, collectively termed the Chuitna Coal Project, on the northwest side of Cook Inlet approximately 70 kilometers (km) west of Anchorage (Figure 1-1). The mine operators plan to extract and transport coal from the mine site via overland conveyor to a port facility to be developed at Ladd Landing, 1.6 km north of the Chuitna River mouth on the western shore of Cook Inlet. OASIS Environmental Inc. (OASIS) designed and implemented a Freshwater Aquatic Biology Program to obtain baseline fisheries information for use in satisfying permitting requirements for this project. An understanding of winter habitat use by fish is important to assess and mitigate habitat loss and biological impacts of the proposed project. This study focuses on juvenile coho salmon and small resident Dolly Varden because of their abundance and because they are considered indicative of the distribution of fish within the system. Though random winter minnow trapping had been completed during previous winters, a specifically designed winter fish habitat program was initiated in October 2007 and continued through May 2008. The study design entailed a juvenile fish mark and recapture program over the course of one winter.

### 1.1. Objectives

The objective of the study was to:

Determine the location, longitudinal movement and habitat use of overwintering fish (emphasis on juvenile coho salmon and small resident Dolly Varden) within randomly selected segments of stream 2003 in the mine area during the winter of 2007/2008.

### 1.2. Coho Salmon Winter Habitat

Coho (silver) salmon (*Oncorhynchus kisutch*) are one of the five species of Pacific salmon that live in Alaska waters. They are a wide-ranging species which spawn in both coastal and inland waters from Alaska to Southern California. Because of their broad range, winter habitat use by coho salmon juveniles is highly variable and dependent upon local climate, physiography, and flow regime conditions across the distribution area.

The availability of winter habitat is critical for coho salmon in some portions of their range to the point that some researchers have suggested it may limit coho salmon smolt production (Nickleson et al. 1992). For example, favorable winter habitat is scarce in Oregon coastal streams. Coho salmon mortality is highest during their juvenile life stage with winter mortality potentially being especially high, between 75 and 90% according to some researchers (Bustard and Narver 1975; Crone and Bond 1976; Quinn and Peterson 1996; Solazzi et al. 2000; Ebersole et al. 2006). Thus this habitat component is likely to exert more control on smolt production than summer rearing habitat which is abundant.

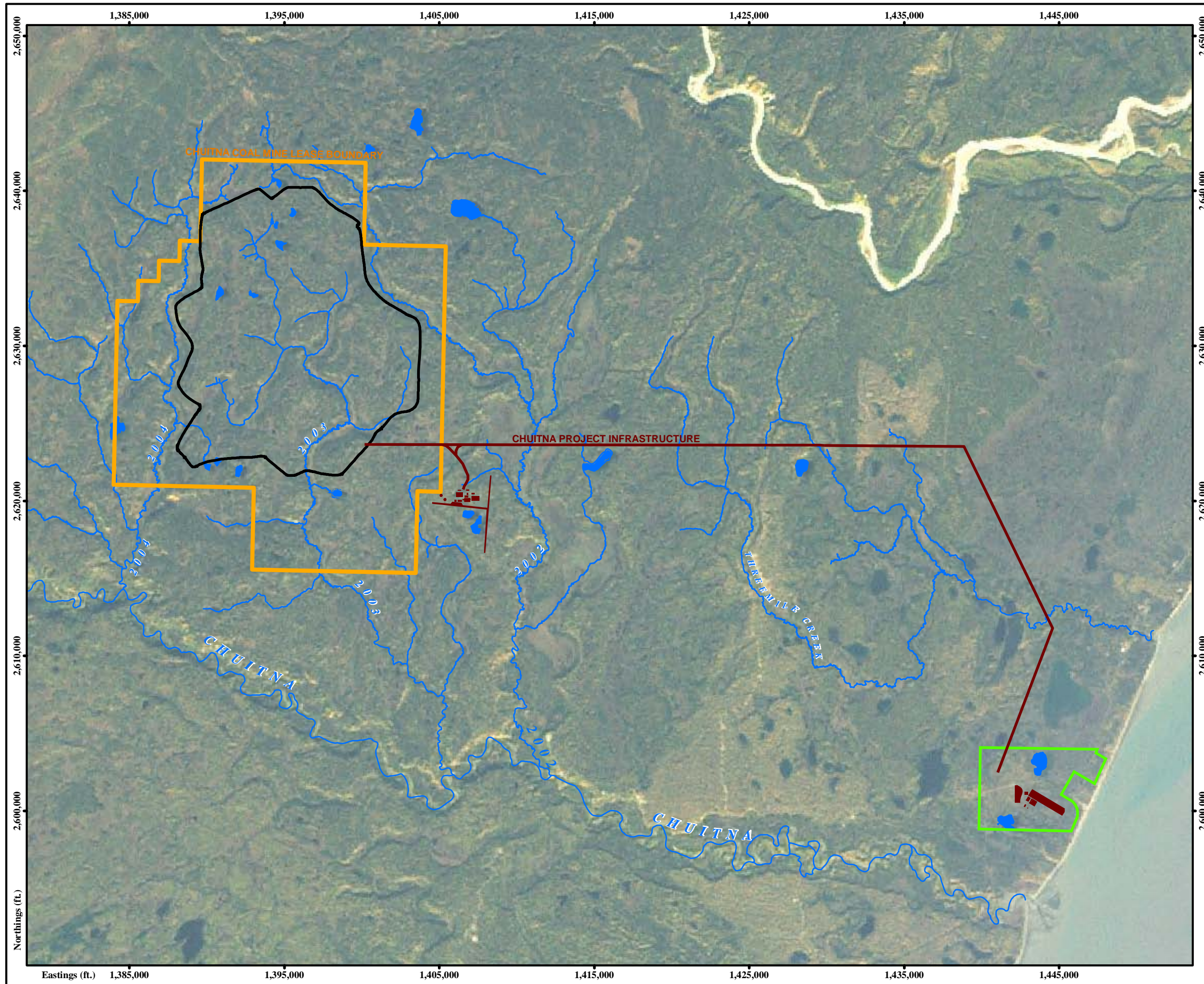
Ideal coho salmon winter habitats should provide adequate protection from freezing, predation, and energy loss (Dolloff 1987). Habitat types that meet these winter

qualifications have been described as pools, side pools, dammed pools, side channels, low-velocity backchannels, alcoves, flooded brush, ponds, beaver ponds, riverine ponds (described as “cut off meander bends”), and other off-channel and pool-like habitats and lower velocity tributaries containing deep pools, logjams and undercut banks (Ruggles 1966; Bustard and Narver 1975; Peterson 1982a and 1982b; Tschaplinski and Hartman 1983; Swales et al. 1986; Nickleson et al. 1992 and Bramblett et al. 2002).

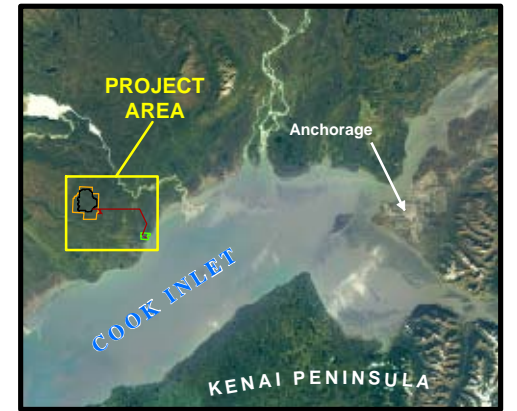
These types of habitats may convey a survival advantage by providing shelter from predators and facilitating “hiding” behavior that minimizes energy loss (Bustard and Narver 1975). Some common features shared by these habitat types were low stream velocity, adequate cover, lack of predators, abundant food supply, and a different, slightly warmer thermal regime than main channel habitats either due to groundwater influx or depth of water such as in beaver ponds (Swales et al. 1986).

Water levels of Oregon coastal streams, in which juvenile coho salmon have been extensively studied, fluctuate periodically from seasonal precipitation events between late fall and spring (Ebersole et al. 2006, Skeesick 1970; Nickleson et al. 1992; Solazzi et al. 2000; Miller and Sadro 2003,). Summer is the dry season in streams of this region. Juvenile coho salmon undertake movements from summer rearing habitats to winter rearing habitats that offer shelter from winter floods or “freshets” (Skeesick 1970). This movement is generally from more mainstem type habitat which provides rearing conditions in the summer but is subject to flooding, into side channel habitats that are less prone to the high flows associated with flooding.

In contrast, some interior streams in British Columbia (which are more similar to Alaska stream systems) such as the Morice and Telkwa Rivers, studied by Bustard (1986), and the Coldwater and Nicola Rivers studied by Swales et al. (1986) sustain summer flows that remain high from May to October due to runoff from glaciers, precipitation events, and snowmelt. In the winter nearly all the precipitation is in the form of snow and the associated hydrograph typically decreases to base flow conditions. Juvenile coho salmon movement to protected side channel and off-channel habitats still occurs but not until spring when this behavior appears to be stimulated by high water caused by melting snow and ice (Bustard 1986; Swales et al. 1986). Faced with winter conditions, but stable flows, juvenile coho salmon and other juvenile salmonids have been observed to make smaller scale movements to deeper water, with a preference for side channels (Swales et al. 1986), and holding more tightly to areas with heavy in-stream cover in the form of bank undercuts, submerged logs and root wads (Bustard and Narver 1975). The timing of these flow-related habitat shifts has implications for growth, survival, in-stream residence time (Nickleson et al. 1992), and smolt production (Bustard 1986).



**FIGURE 1-1  
PROJECT LOCATION MAP**



**FIGURE LOCATION MAP**

**Legend**


-  Project Area Stream
-  Project Area Lake
-  Proposed Road & Conveyor
-  Proposed Facilities
-  Ladd Landing Boundary
-  Lease Mining Unit-1 Boundary
-  Lease Boundary

**Data Sources:**

Benthic Macroinvertebrate Survey Sites, Oasis, 2007.  
 Zooplankton Survey Sites, Oasis, 2007.  
 Mine Infrastructure, Mine Engineers, 2006.  
 Hydrology, Oasis, 2007.  
 USGS Topographic Quadrangle, 1:63360,  
 Tyonek Sheets A2, A5, & A7, 1958.



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### 1.3. Dolly Varden Winter Habitat

The common char in Gulf of Alaska drainages is the southern form of the Dolly Varden (*Salvelinus malma*) (Behnke, 1980). More recently Behnke (2002) states that the distribution of the northern form Dolly Varden includes the southern drainages of the Alaska Peninsula to the Susitna River. The Chuitna River is within the range of overlap of the two dominant forms of Dolly Varden in Alaska. Although we consider these to be southern form fish, diagnostic meristic characters have yet to be examined (pers. comm. F. DeCicco). Dolly Varden are common and often abundant in coastal streams such as the Chuitna River and its tributaries. Dolly Varden undergo partial migrations in that some but not all emigrate from their natal streams during the non-breeding seasons. Char are among the fish species that have migrant and non-migrant components of the population with migrants typically growing larger and having much higher fecundity but lower survival rates than non-migrants (Jonsson and Jonsson 1993).

Growth rate may influence the adoption of one life history strategy over the other (Grand 1999). For instance, an energetic incentive may exist for fish to delay maturity, become anadromous and achieve a larger body size by traveling to an area where the food supply is greater, i.e. the ocean, thereby increasing the fish's fitness. The alternative is to adopt a stream-resident life history strategy, remain small, spawn at a younger age, produce fewer gametes but have more mating opportunities while risking less mortality (Jonsson and Jonsson 1993). It is likely that there are genetic (growth/metabolic rate) as well as environmental components (habitat) that drive these divergent strategies and also affect the timing of migration (Jonsson and Jonsson 1993). Armstrong (1974) noted that Southeast Alaskan Dolly Varden rearing in non-lake systems (rivers that do not have a headwater lake) smolted as 2.0 to 4.0 year old (y.o.) fish and Dolly Varden rearing in lake-stream systems smolted in May and June as 3.0 and 4.0 y.o. The non-anadromous stream-resident form matures at a very small size and has greatly reduced fecundity (Armstrong and Morrow 1980). Small resident Dolly Varden that spend their entire lives in freshwater rarely exceed 26 cm in total length (TL) (Armstrong 1991) and retain parr marks and other juvenile characteristics (paedomorphosis) throughout their lives (Armstrong and Morrow 1980). Bramblett et al. (2002) documented mature male Dolly Varden in Southeast Alaska, as small as 102 millimeter (mm) fork length (FL), freely expressing milt. In the interest of clarity in this report, both juvenile and mature stream residents are collectively referred to as small resident Dolly Varden.

Immature (non-spawning) anadromous Dolly Varden may range widely in search of food and may be present in water bodies far from streams where they spawn or overwinter (Armstrong 1974). While at sea, anadromous Dolly Varden were previously believed to remain in near-shore coastal waters however one tagging study has documented long-range movements (1690 km) between Northern Alaska and Russia (DeCicco 1992). Anadromous Dolly Varden migrate from the sea to overwinter in freshwater habitat, such as lakes or spring influenced areas in rivers (DeCicco 1996, 2001). Based on anecdotal reports of fish being caught in salt water during winter months, Bernard et al. (1995) hypothesized that some anadromous Dolly Varden in the Gulf of Alaska may remain at

sea during part of the winter. It is likely that at least some interbreeding occurs between the anadromous and stream resident sub-populations of the Chuitna Basin.

To date few studies have been conducted on small resident Dolly Varden because they are not part of any sport, commercial or subsistence fishery (Armstrong 1991). However, small, resident Dolly Varden are known to orient themselves to the bottom of streams and most food is obtained there (Armstrong and Morrow 1980). They eat insects (both aquatic and terrestrial), insect larvae, other fish, fish larvae, and salmon eggs (Armstrong 1991). Small resident Dolly Varden grow quite slowly under these conditions (Armstrong and Morrow 1980) and they are known to be one of the most thermally sensitive of the salmonids. There is likely substantial overlap in winter habitat use between resident Dolly Varden and juvenile coho salmon (Swales et al. 1986) with the former preying upon small individuals of the latter group. Swales et al. (1988) noted that where small resident Dolly Varden and juvenile coho salmon occupied the same winter habitat, Dolly Varden were not as closely associated with bankside cover as coho salmon.

In a study conducted in Southeast Alaska the majority of small resident Dolly Varden seasonal fall movement was in a downstream direction as opposed to juvenile coho salmon which moved both up and downstream (Bramblett et al. 2002). In another study undertaken on interior streams of British Columbia both small resident Dolly Varden and juvenile coho salmon preferred side channels over main channels during winter (Swales et al. 1986).

#### **1.4. Chuitna Watershed Winter Conditions**

Winters in Southcentral Alaska are long and cold and it is not uncommon for the surfaces of streams, rivers, and lakes to freeze solid with accumulations of deep snow. Some rivers in Alaska's interior and northern regions freeze solid to the river bottom. However, conditions can vary according to location and year, depending on climatic fluctuations each winter. Most rivers and streams do not freeze to the bottom and there are also ice-free stream reaches that remain open due either to turbulence or groundwater influence for most or all of the winter. Due to these climatic and environmental conditions, winter habitat that is available in more southerly latitudes (e.g. Southeast Alaska) may not be available or may be limited in Southcentral Alaska and stream icing may limit the options for juvenile coho salmon and small resident Dolly Varden to move into more favorable habitats.

##### **1.4.1. Stream 2003**

The Chuitna watershed contains all of the winter conditions described above. These conditions are dynamic within each winter season, from year to year, and by location in the watershed. During the winter of 2007/2008, the surface of stream 2003 was blanketed with snow and ice with short sections of open water. Generally, snow depths were greatest in the upper portion of stream 2003, while ice thickness was greatest in beaver ponds and in the lower reaches of the stream closer to the Chuitna confluence.

Heavy snow accumulations of two to three meters were encountered during 2008 winter sampling in the headwater areas of stream 2003 (Figure 1-2). Under the snow, typical ice cover thickness was between 5 and 10 cm in flowing water and up to one meter thick in beaver ponds by March. Ice over beaver ponds existed in a series of layers with liquid water in between, most likely from overflow as snow accumulation weighted the ice. Some small areas of open water (less than three meters in length) existed where snow bridges had collapsed, but these areas were not consistently open. Shallow water conditions existed below the snow and ice with depths typically one half to one quarter the depths encountered at the same sites during normal summer flows, but similar to extreme summer lows (RTi 2007). Very little frazzle or bottom-fast ice was encountered during the 2008 winter surveys, and most of it was encountered in December. Crews that attempted to minnow trap in the headwater areas of stream 2003, during the previous winter (February 2007), encountered such heavy slush and bottom-fast ice that trap placement was not feasible. However, these conditions were never encountered during the 2008 winter surveys, indicating high year-to-year variation in winter fish habitat conditions.



**FIGURE 1-2: SNOW CONDITIONS ENCOUNTERED MARCH 24, 2008 IN HEADWATER AREAS OF STREAM 2003 (SITE E\_3).**

Snow depths were typically one to two meters in the middle portion of stream 2003 and there were more consistent and longer stretches of open water (up to fifteen meters in length) than locations upstream. Where snow cover and flow were present, maximum ice thickness was 7.5 cm but typically closer to 2.5 cm. Beaver ponds were covered in thick layers of ice (approximately one meter by March) with a thin ice layer or small area of open water present at the dam. Again, flows were typically one half that encountered during typical summer flows (RTi 2007). Longer stretches of open water in this section

were most likely due to greater stream widths, less snow, higher flow volume, and potentially from the higher occurrence of streamside seeps. Only one seep was observed in the upper reaches of the stream (in the northeast fork, above site D-4), while most seeps were concentrated within the southern half of the mine area and originated from the west side of the valley(Figure 1-3, Figure 1-4, Figure 1-5).



**FIGURE 1-3: LOOKING DOWNSTREAM NEAR THE MINE AREA BOUNDARY WITH HILLSIDE SEEP FLOWING INTO THE STREAM 2003.**



**FIGURE 1-4: SOURCE OF HILLSIDE SEEP LOCATED 1.5 METERS ABOVE AND 12 METERS WEST OF STREAM 2003 WITH A WATER TEMPERATURE OF 3.3 °C, MARCH 25, 2008.**



**FIGURE 1-5: ANOTHER HILLSIDE SEEP IN MIDDLE REACHES OF STREAM 2003 LOCATED NEAR THE SOUTHERN MINE AREA BOUNDARY SHOWING GREEN VEGETATION THROUGHOUT THE WINTER OF 2007/2008.**

The lowest reaches of stream 2003, (below the mine area and close to the Chuitna confluence) were covered in thick ice (up to 15 cm thick), less snow cover (typically one meter after December), and areas of overflow. Ice conditions were less stable in the lowest reaches where overflow created new areas to freeze and shifted the stream flow in places. However, these conditions were in discrete locations and deep, stable pools and runs were common. Open areas existed where riffles and turbulence was great enough to inhibit ice formation (Figure 1-6).



**FIGURE 1-6: SITE CONDITIONS IN STREAM 2003 ON APRIL 21, 2008 APPROXIMATELY 100 METERS UPSTREAM OF CONFLUENCE WITH THE CHUITNA.**

Variable and extreme conditions occurred over the course of the winter with ice cover sporadic and thin until December when the main channels of the tributary streams began

to freeze solid. As mentioned above, ice thickness ranged from centimeters to meters to absent depending on environmental and geomorphic processes.

## 2. METHODS

### 2.1. Study Design

Mark, re-capture methods were used to determine the location and longitudinal movements of juvenile coho salmon and small resident Dolly Varden in winter. Habitat use was determined by descriptions of capture and re-capture sites, through direct measurement and visual observation and through the use of underwater video photography.

Visual Implant Elastomer (VIE) tags were used to mark juvenile coho salmon and Dolly Varden for the mark and recapture portion of the study. The elastomer is a two-part polymer that produces a brightly colored liquid which hardens into a flexible, color-coded tag when injected subcutaneously. The VIE tagging method has high rates of tag retention and is less likely to affect the behavior, growth, or swimming performance of fishes than other tagging methods (Bailey et al. 1998; Olsen and Vollestad 2001). Another advantage to VIE tags is that they can be used to mark very small fish (OASIS tagged a 40 mm fish) increasing their value in this. VIE tags have been successfully implanted in even smaller salmonids (Olsen and Vollestad 2001). More information on VIE tags and a reference list of case studies can be viewed on the manufacturer's website: <http://www.nmt.us/index.htm>.

Fish were tagged in the fall (September 24-October 25, 2007) released and then recaptured throughout the winter (October 24, 2007-May 15, 2008) (Table 2-1). Data on the direction, and distance of fish movement, habitat use, and month to month variation in catch was collected and analyzed using regression and analysis of variance (ANOVA, 95% confidence interval).

**TABLE 2-1: COHO SALMON AND DOLLY VARDEN TAGGING**

Tagging Site	Body Location and Tag Color	Coho Salmon Marked	Dolly Varden Marked	Total Marked	Date of Tagging
A	Left eye, orange	291	8	299	10/3/2007
B	Left eye, yellow	347	16	363	10/4/2007, 10/25/2007
C	Anal fin, red	243	7	250	9/28/2007
D	Right eye, orange	549	46	595	10/11/2007, 10/12/2007
E	Left eye, red	177	23	200	9/27/2007
H	Anal fin, yellow	83	2	85	9/25/2007
I	Right eye, red/Anal Fin, yellow	182	22	204	9/24/2007, 9/26/2007
J	Anal Fin, orange	35	1	36	10/5/2007, 10/24/2007
		<b>1,907</b>	<b>125</b>	<b>2,032</b>	

An underwater video camera was used to augment the mark and recapture study. Underwater cameras have been successfully used to observe fish in many open water environments including both fresh and salt water. They have also been successfully used in under-ice work in large rivers and lakes. However, similar to other sampling methods, little work has been done under the ice in small streams. The primary use of

the camera was to locate fish in habitats under the ice that were not accessible to minnow traps such as riffles and swift runs.

## **2.2. Initial VIE Tagging Site Selection**

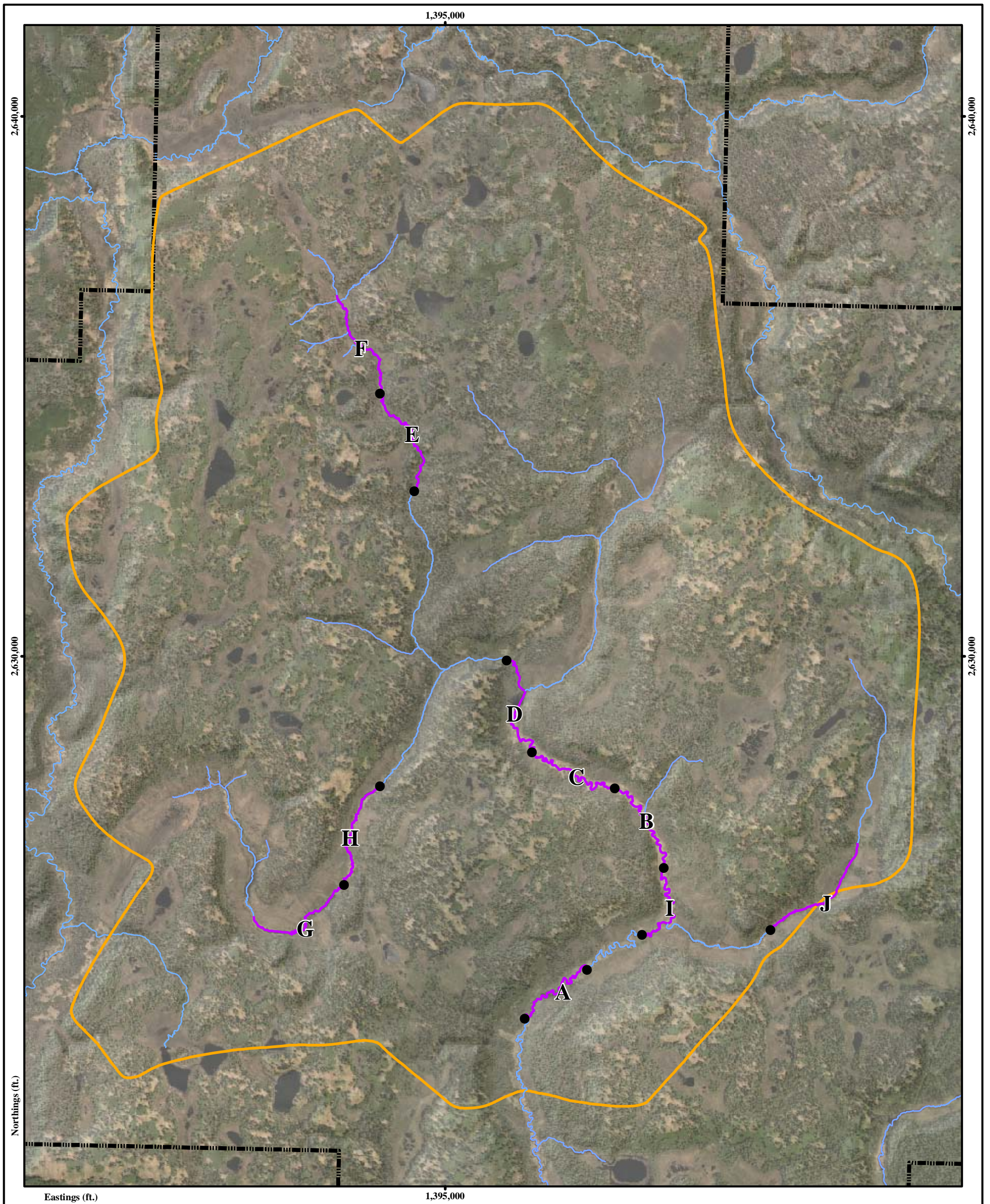
Stream 2003 and its major tributaries within the mine area were divided into 20 one-half-mile segments. Ten of the 20 one-half-mile segments were selected at random as capture sites for VIE tagging. To insure each river segment had an equal probability of being selected, OASIS assigned each of the 20 river segments a number (1 through 20). A random number generator program was then employed to choose 10 of the 20 numbers. Each selected stream segment was then assigned a letter (A through J) (Figure 2-4). A goal of 2,000 tagged fish was set (at least 200 fish from each of the 10 randomly selected segments) based upon an estimate of capture and tagging capabilities prior to the onset of winter. Within the 10 random segments, trapping locations included all habitat types (riffle, run and pool) previously described in the OASIS Annual Reports (OASIS 2007, 2008) that were located in the proposed mine area.

## **2.3. Field Methods**

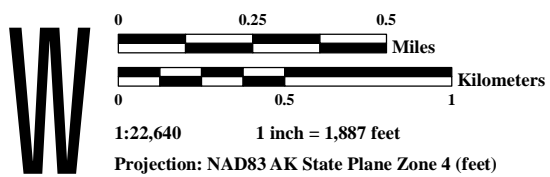
Fish for VIE marking were caught in minnow traps and hoop nets baited with cured salmon roe and fished from 4 to 24 hours. Fish trapping and handling procedures followed those outlined in OASIS 2007. Fish were anesthetized in an ethanol-clove oil solution, identified to species, measured, marked, allowed to recover, and then released. Clove oil solution concentration was increased from 0.5 milliliters (ml) (the concentration typically used during summer minnow trapping) to 0.75 ml. This was done in order to achieve the desired effect quickly, and reduce handling time because fish react more slowly to clove oil in cold water.

### **2.3.1. Fish Tagging**

All handling of the VIE material was in accordance with the manufacturer's (Northwest Marine Technologies; NMT) instructions. The silicon-based VIE material was mixed, immediately prior to use, with a curing agent in a 10:1 ratio. Unmixed elastomer was kept cool to maximize shelf life. Mixed elastomer was kept on ice to extend its plasticity. Any mixed elastomer that was not used within 48 hours was discarded. The tags were implanted beneath transparent or translucent tissue using a 0.3 cc insulin syringe with a 29 gage needle (Figure 2-1). The tags remain externally visible but viewing can be enhanced by using a deep purple light (405 nanometers) which fluoresces the tags and aids in identification upon recapture (Figure 2-2).



**FIGURE 2-4 VIE TAGGING SEGMENTS, 2007.**



**CHUITNA COAL PROJECT**



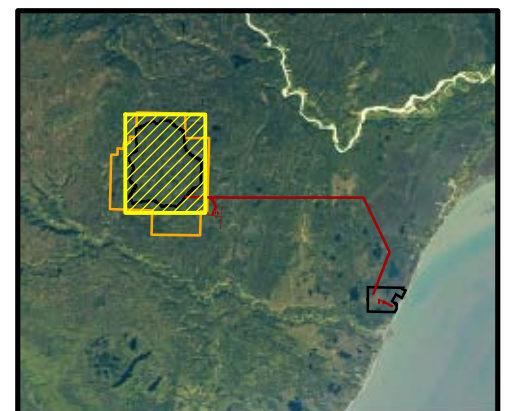
PacRim Coal, LP  
 711 H Street, Suite 350  
 Anchorage, AK 99501 USA  
 Phone: (907) 276-6868

**Legend**

- VIE Tagging & Recapture Segment
- Project Area Stream
- Lease Mining Unit-1 Boundary
- Lease Boundary

**Data Sources:**

VIE Tagging & Recapture Segments, Oasis, 2007.  
 Mine Infrastructure, Mine Engineers, 2006.  
 Hydrology, Oasis, 2007  
 USGS Topographic Quadrangle, 1:63360,  
 Tyonek Sheets A2, A5, & A7, 1958.

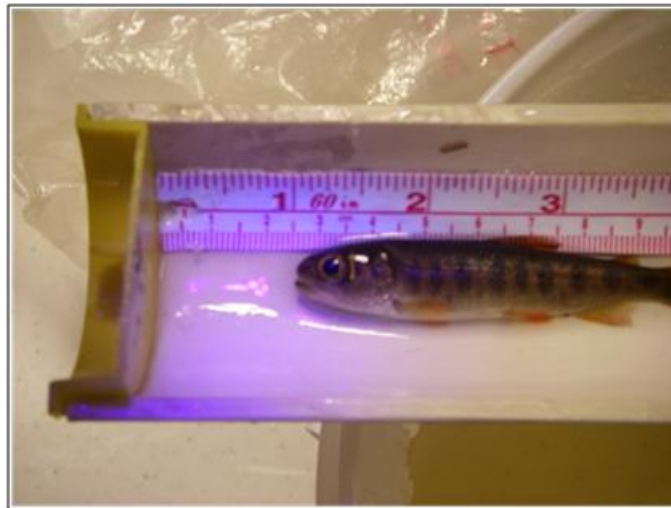


**FIGURE LOCATION MAP**

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**FIGURE 2-1: FISH TAGGING WITH VISIBLE IMPLANT ELASTOMER (VIE).**



**FIGURE 2-2: VIE TAGGED COHO; NOTE ORANGE STRIPE BEHIND THE LEFT EYE.**

Fish from each randomly selected segment were batch tagged with one of three colors in one of three body locations (post-ocular right side, post-ocular left side, base of the anal fin). One exception to this was stream segment "1" where two colors were used in two body locations (post-ocular and anal fin). In order to minimize the potential for confusion in the event of tag loss it was subsequently decided to use only one color per fish and tag one body location only, for the remainder of the selected stream segments.

As field crews became adept at VIE tagging, incidence of fish mortality decreased and the number of fish marked per hour increased to approximately 90 fish per hour. Tagging mortality was low for juvenile coho salmon (4%; n=83) and very low for Dolly Varden (0.7%; n=1). Tagging capability also increased with the addition of propane heaters for hand warming of field personnel. Early winter storms and fog frequently curtailed tagging missions.

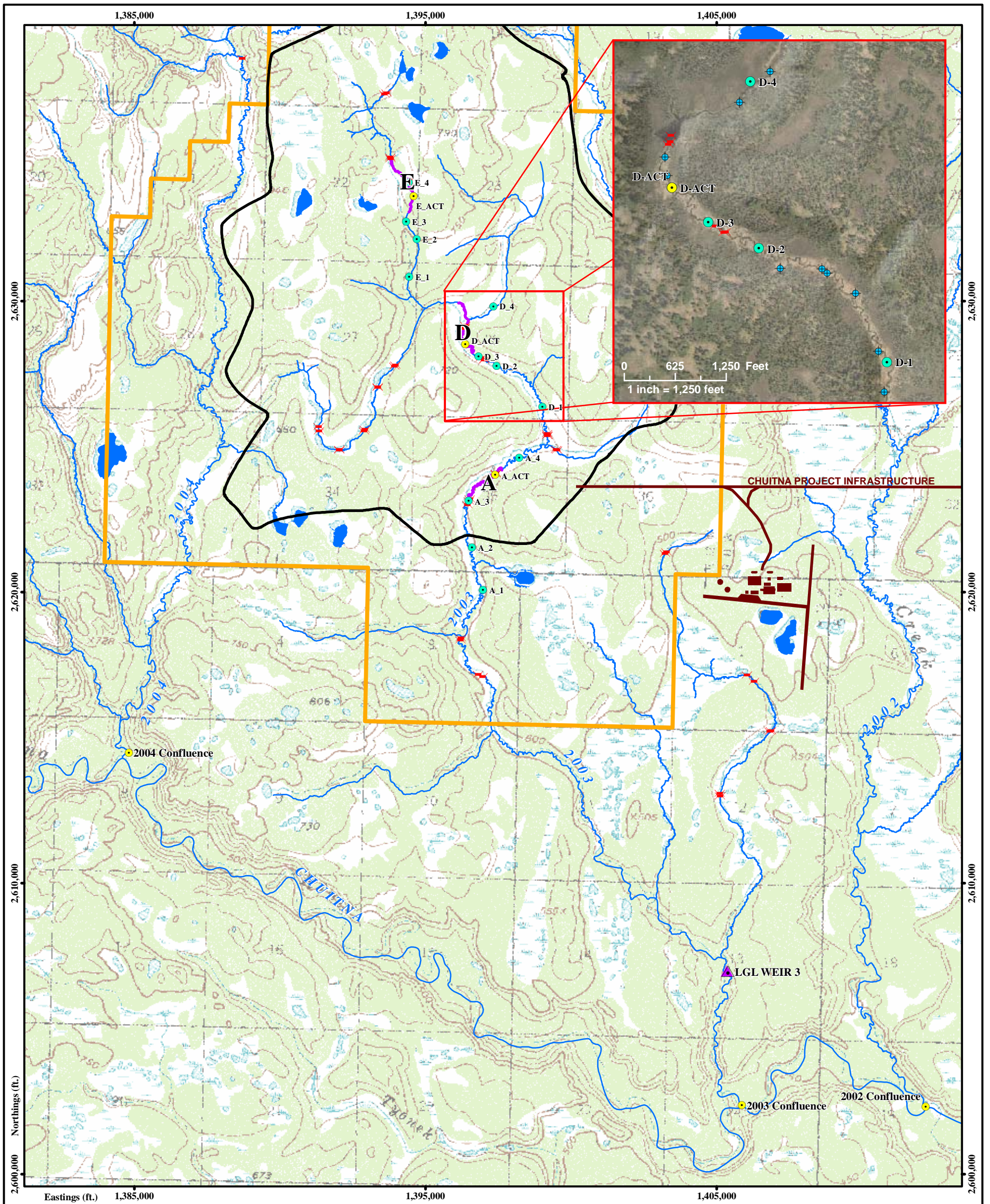
### 2.3.2. Recapture

Winter weather made for challenging minnow trapping conditions including minnow traps freezing to the bottom or filling with slush (Figure 2-3), and fish freezing to measuring boards. Occasionally and depending on stream flow and weather conditions, traps filled with slush or ice, effectively blocking fish entrance to the trap. Trap placement became important in overcoming slush or freezing issues, but was not always avoidable and researchers noted and discarded trap data when it occurred. Weather conditions were most severe in December with daytime temperatures between -21 °C and -29 °C. During December some fish froze when exposed to air and had to be transported by helicopter, in buckets of river water, to a heated facility for processing. After recovery, fish were flown back and released at the recapture site. Fish could be safely handled on site at temperatures of -21 °C and warmer provided there was no wind. After December, increased daylight and more mild temperatures made minnow trapping less problematic and frozen traps and bottom-fast ice were not present after January.

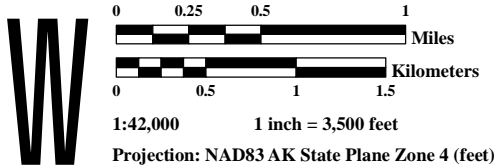


**FIGURE 2-3: MINNOW TRAP FILLED WITH SLUSH AND CONTAINING BOTTOM-FAST ICE.**

Recapture of VIE tagged fish by minnow trapping began October 25, 2007 and continued monthly throughout the winter (Table 2-2). Trapping locations were marked in the field prior to snowfall with eight-foot long florescent orange fiberglass poles in anticipation of heavy snow cover throughout the winter trapping period. Each pole was marked with the site location identifier, direction, and distance to potential trap positions. Most trapping occurred within the mine area of stream 2003 at specific locations as discussed below. Spot check locations were also established at the mouths of streams 2002, 2003, and 2004 to determine if tagged fish were moving between drainages (Figure 2-7). Catch data from these sites were included in the month to month catch per unit effort (CPUE) comparison analysis.



**FIGURE 2-7 VIE TAGGING & RECAPTURE SITES, WINTER 2007-2008.**



**CHUITNA COAL PROJECT**

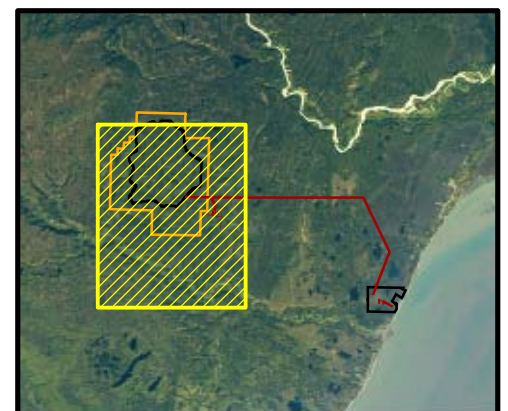


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**Data Sources:**  
 VIE Tagging Sites & Segments, OASIS, 2007.  
 LGL Tagging Site, LGL, 2008.  
 Beaver Dams, OASIS, 2007.  
 Seeps, OASIS, 2007.  
 Mine Infrastructure, Mine Engineers, 2006.  
 Hydrology, Oasis, 2007  
 USGS Topo Quadrangle, Tyonek, 1958, 1:63360.

**Legend**

- Seep
- VIE Recapture Site
- VIE Tagging & Recapture Site
- LGL Weir 3
- Beaver Dam
- VIE Tagging Segment
- Project Area Stream
- Project Area Lake
- Proposed Road & Conveyor
- Proposed Facilities
- Lease Mining Unit-1 Boundary
- Lease Boundary



**FIGURE LOCATION MAP**

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Winter trapping efforts focused on three VIE tagging segments: A, D, and E (Figure 2-7). These recapture locations were selected based upon three factors:

1. A minimum of 200 fish were trapped and tagged in each segment;
2. There was sufficient longitudinal separation between these segments to allow for recapture location spacing and placement without trap overlap; and
3. The estimated wintertime sampling capability.

Five recapture stations were established in each of the river segments (A, D, E) yielding a total of 15 recapture stations. One recapture station was placed 200 m upstream of the original VIE tagging site, one station was placed at the original VIE tagging site, and three stations were placed 200 m, 400 m and 800 m downstream of the original VIE tagging site (Figure 2-7). This sampling design allowed for the detection of longitudinal movement of marked fish within the stream segment and between segments. The bulk of the recapture stations (three of five) were placed downstream of the tagging sites which reflected an expectation that the majority of juvenile coho salmon and Dolly Varden wintertime movement would be in a downstream direction to avoid the energetic cost of swimming against the stream current. Two minnow traps at each of the 15 recapture stations were deployed monthly.

**TABLE 2-2: RECAPTURE SAMPLING EVENTS- WINTER 2007/2008.**

Recapture Stations	October 21-26	November 26-29	December 17-20	January 21-25	February 18-22	March 24-28	April 21-25	May 12-15
A_1			X	X	X	X	X	X
A_2	X*		X	X	X	X	X	X
A_3			X	X	X	X	X	X
A_4		X**	X	X	X	X	X	X
A_ACT			X	X	X	X	X	X
D_1	X***			X	X	X	X	X
D_2				X	X	X	X	X
D_3				X	X	X	X	X
D_4				X	X	X	X	X
D_ACT		X		X	X	X	X	X
E_1				X	X	X	X	X
E_2				X	X	X	X	X
E_3			X	X	X	X	X	X
E_4			X	X	X	X	X	X
E_ACT	X^	X^	X	X	X	X	X	X
2002_CON				X	X	X	X	X
2003_CON					X	X	X	X
2004_CON		X			X	X	X	X

\* recorded in data as site 2003-6

\*\* recorded in data as site W2003-6

\*\*\* recorded in data as site 2003-10

^ recorded in data as site 2003-14

To delineate patterns of habitat use, three broad habitat categories were assigned to recapture stations: small channel (1-2 m channel width), large channel (3-4 m channel width), and beaver pond (main channel impoundments caused by beaver dams). Minnow traps were baited with cured salmon roe and fished for approximately 24 hours. Though recapture sampling was scheduled to occur at each site during all months,

coverage was sporadic in October, November and December, 2007, due to hazardous flying conditions and safety concerns. In October, November and December, 2007, 3, 4 and 8 recapture stations, respectively, were trapped out of the total 15 recapture stations. In January, February, March, April and May, 2008 all 15 stations were sampled using minnow traps (Table 2-2). Due to sporadic sampling coverage in October, November and December, 2007, these three months were omitted from monthly CPUE analysis. However, recapture data from October, November and December, 2007, were included in movement and habitat use analysis.

### 2.3.3. Underwater Video Recording

OASIS submerged an underwater camera into riffle and fast run habitats in both small and large channel habitat categories. OASIS also used the camera in beaver ponds to visually compare minnow trap catches to numbers of fish viewed with the camera. Stream habitats and beaver ponds that had potential as camera sites were marked prior to freeze up in a similar manner to the minnow trapping sites. An orange pole was used to mark the upstream and downstream extent of the sampling location (Figure 2-5). The locations for underwater video were concentrated within and downstream of the proposed mine site in stream 2003 and other locations in streams 2002 and 2004 (Figure 2-8).



FIGURE 2-5: FIELD CREW MARKING A TYPICAL CAMERA LOCATION PRIOR TO FREEZE-UP.



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After freeze-up a hole large enough to insert the camera into the water column was drilled or chipped through the ice. The camera was attached to a top set wading rod, placed through the hole, and aimed downstream. Salmon roe, contained in nylon mesh bags, was attached to the base of the camera for bait. Observations were recorded to digital video disks (DVDs). Fish spotted were identified to species where possible and a description of the habitat (riffle, run or pool) was noted. Researchers also looked for VIE tagged fish. Observations at each location were made for a minimum of 30 minutes and occasionally longer.

Observations were made under different light conditions; natural light, artificial white light and UV light at some sites but artificial white light was primarily used because it offered the greatest horizontal range for video recording (Figure 2-6).



**FIGURE 2-6: CAMERA BODY AND ATTACHED LIGHT SOURCE BEING LOWERED THROUGH THE ICE OF STREAM 2003.**

Camera equipment consisted of an underwater video camera connected to a video monitor and DVD recorder with a 12-volt battery for power to the system. The camera was deployed following VIE recapture events during January, February, March, and April 2008.

## 2.4. Data Analysis

Differences in coho salmon CPUE for all fish captured were tested using linear regression and ANOVA. The log-transformation  $\log(\text{CPUE}+1)$  was used to meet the assumption of normality and equal variance. Changes in CPUE over time (January to May) were tested for significance using linear regression to describe the overall trend and ANOVA to determine significant differences among months. The null hypothesis was:

*$H_0$ : There is no difference in mean CPUE between months.*

vs.

*$H_A$ : There are significant differences in mean CPUE between months.*

Differences in juvenile coho salmon CPUE between habitat types were tested using ANOVA. The null hypothesis was:

*$H_0$ : There is no difference in mean CPUE between habitat types.*

vs.

*$H_A$ : There are significant differences in mean CPUE between habitat types.*

The longitudinal distance in meters of recaptured fish from their site of tagging was tested for significance using a t-test. The null hypothesis was:

*$H_0$ : The mean distance from site of tagging for recaptured fish was not different from zero.*

vs.

*$H_A$ : The mean distance from site of tagging for recaptured fish was different from zero.*

### 3. RESULTS

2,032 fish were marked with VIE tags including 1,907 juvenile coho salmon and 125 Dolly Varden between September 24th and October 25, 2007, at eight randomly selected segments on stream 2003 (Table 3-1). Two other sites (F and G, Fig 2-4) yielded zero fish. Variation in the number of fish per site generally reflects the abundance of fish that were present in each particular stream segment at the time of trapping (OASIS 2007, 2008).

**TABLE 3-1: NUMBERS OF TAGGED AND RECAPTURED FISH BY SPECIES.**

Tagging Site	Coho Marked	Coho Recapture	Recapture Stations	DV Marked	DV Recapture	Recapture Stations
A	291	11	A_ACT (10), D_ACT (1)	8	1	A_ACT (1)
B	347	4	D_1 (4)	16	0	n/a
C	243	0	n/a	7	0	n/a
D	549	34	D_ACT (26), D_3 (1), D_4 (7)	46	0	n/a
E	177	30	E_ACT (29), D_3 (1)	23	4	E_ACT (1), E_2 (1), E_3 (2)
H	83	0	n/a	2	0	n/a
I	182	3	A_ACT (1), A_4 (2)	22	1	A_4 (1)
J	35	0	n/a	1	0	n/a
<b>Total</b>	<b>1,907</b>	<b>82</b>		<b>125</b>	<b>6</b>	

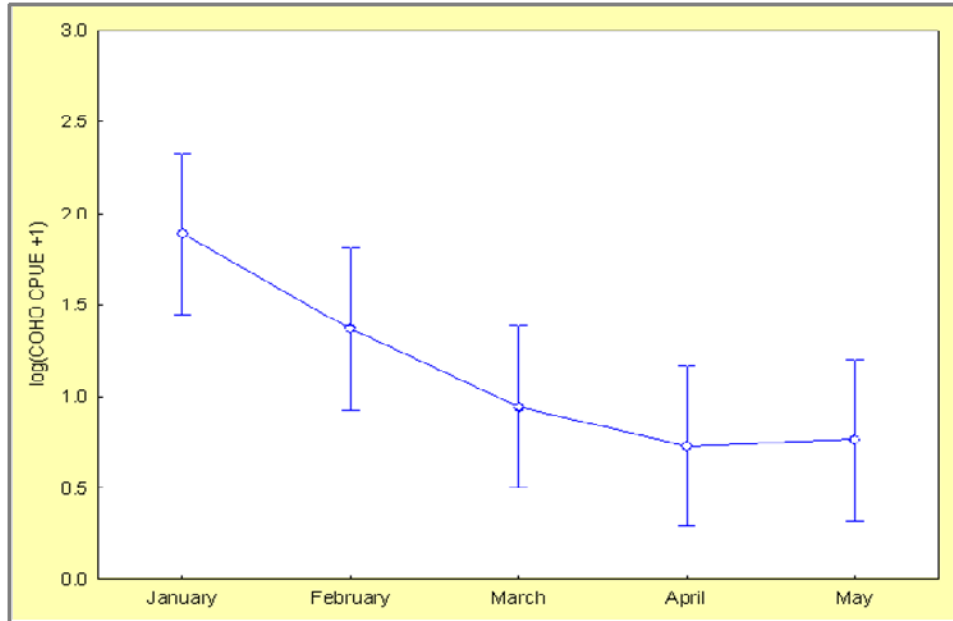
DV: Dolly Varden

A total of 88 VIE marked fish, 4% of the total number marked, was recaptured during monthly sampling between October 2007 and May 2008. The 4% figure assumes a 5% tag loss thus making the calculation based on a total number of fished marked of 1,931 (Bailey et al. 1998) and no marked fish was captured twice. Of the 88 recaptures, 82 were juvenile coho salmon and six were Dolly Varden (Table 3-1). Dolly Varden were recaptured in the same proportion to the number that were tagged ( $125/2,032 = 6\%$ ;  $6/88 = 6\%$ ). Due to the small recapture sample size of Dolly Varden ( $n=6$ ) they were excluded from the statistical analysis except for movement distance analysis. Tagged fish from five of the original eight tagging sites were recaptured at the 15 selected recapture stations in the three river segments (A, D, E). Marked fish were recaptured during every sampling month with the highest number of recaptures occurring in January, 2008 ( $n=32$ ) and the lowest in the months of March ( $n=2$ ), and May ( $n=2$ ), 2008 (Figure 3-1). Coho CPUE decreased over time with significantly fewer fish found in April and May as compared to January:  $F(4,145)=4.8441$ ,  $p=.00107$  (Figure 3-1).

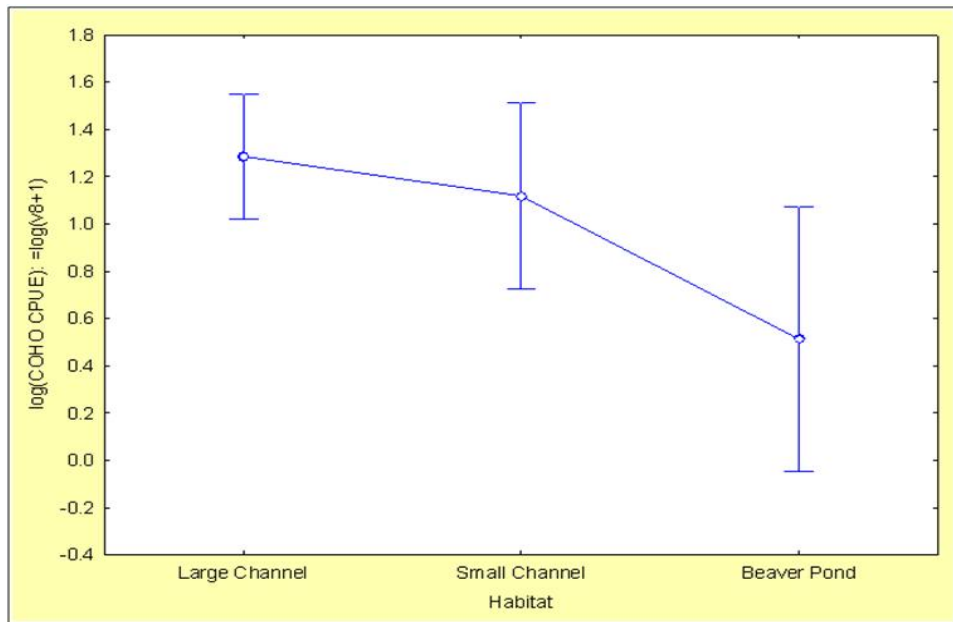
#### 3.1. Habitat Use

Three broad categories were used to characterize the recapture sites: Large channel ( $n=8$ ), small channel ( $n=4$ ), and beaver pond ( $n=3$ ). Most fish were recaptured in large channel habitat ( $n=47$ ), followed by small channel habitat ( $n=34$ ), and beaver ponds ( $n=7$ ) (Appendix 1). Overall CPUE was higher in large channel habitat but with weak significance ( $p=.05097$ ) (Figure 3-2). For the most part, tagged fish remained in the same habitat category and location in which they were originally tagged, remaining there throughout the winter, with two notable exceptions. In the first case, a 92 mm total length

(TL) age 1.0 juvenile coho salmon migrated from small channel habitat and was recaptured in a beaver pond 1,000 m downstream. In the second case a 52 mm TL age 1.0 juvenile coho salmon migrated from a large channel habitat and was recaptured in a beaver pond 200 m downstream. Tagged fish were not recaptured at any of the stream confluences nor in streams 2002 or 2004.



**FIGURE 3-1: WHISKER PLOT OF CPUE DATA COMPARING MONTHLY CATCH OF JUVENILE COHO SALMON:  $F(4,145)=4.8441$ ,  $P=.00107$ .**



**FIGURE 3-2: WHISKER PLOT COMPARING JUVENILE COHO SALMON CPUE BY HABITAT TYPE.  $F(2, 147)=3.0376$ ,  $P=.05097$ .**

### 3.2. Winter Movement

The majority of fish (81% of the total recaptures) were recaptured at their original VIE tagging site (n=71). Upon recapture, four of a total of six Dolly Varden (66%) had moved at least 200 m from their original tagging site. In comparison, only 12 out of 82 (or 15%) of recaptured juvenile coho salmon had moved at least 200 m from their original tagging sites. Among recaptured fish that moved, upstream movement (n=8) was as common as downstream movement (n=8) (Appendix 1). Movement direction by species was 100% downstream for Dolly Varden and 33% downstream for juvenile coho salmon. However, a test for significance ( $\alpha=0.05$ ), using a two-sided t-test revealed that the average upstream and downstream movement of both Dolly Varden and juvenile coho salmon was not significantly different than zero and had a very high standard deviation (571 m and 233 m respectively for coho salmon and Dolly Varden) (Table 3-2). There was scatter both upstream and downstream indicating some fish movement with an insignificant downstream tendency. High variability in movement patterns indicated some fish were moving but, overall, most fish remained in close proximity to their original capture and tagging site throughout the winter.

**TABLE 3-2: FISH MOVEMENT DISTANCE IN METERS.**

	<b>Coho Salmon</b>	<b>Dolly Varden</b>
mean in meters (negative reflects downstream movement)	-76.20	-85.70
standard deviation	570.99	232.99
n (sample size)	82.00	6.00
standard error	63.04	95.12
lower bound of 95% confidence interval	-201.63	-330.22
upper bound of 95 % confidence interval	49.24	158.80
t-test	-1.20	-0.90
P-Value	0.23	0.41

### 3.3. Underwater Video Recording

In January the underwater camera was deployed at the mouth of stream 2003 (Figure 3-3) (Table 3-3). No fish were observed. Visibility with the light attachment was approximately 1.5 m. The camera was deployed in approximately 10 cm of flowing water to sample water too shallow and fast for minnow traps. The ability to use the camera in these conditions met two of the study objectives, documenting the presence of overwintering fish and describing their habitat.

In February the underwater camera was deployed at three locations in stream 2003. One location was at the interface between run and pool habitat types, and the other two locations were run habitat types (Table 3-3). No fish were observed. Visibility with the light attachment was approximately one meter. Field crews placed bait in the water to attempt to draw fish into the camera view.

During the months of March and April, the underwater camera was deployed at nine locations total in each month; six in stream 2003, two in stream 2004 and one in stream 2002, and a total of 553 minutes of video was recorded (272 in March and 281 in April). Habitat at the nine sites varied between pool, run and riffle habitats. Juvenile coho salmon were observed at sites in stream 2003, in shallow run/riffle habitat ranging from 10 cm to 3.5 m deep (Table 3-3). Additional underwater lights were used beginning in March, which improved the overall visibility and extended the view to approximately two meters. Bait was again used to draw fish to the camera location, and appeared to be successful, as noted by the behavior of the juvenile fish swimming directly towards the bait and remaining in the vicinity of the bait for an extended period of time. This included drawing fish from pool habitat into shallow riffle habitat to investigate the scent of food. In May, high turbidity caused by snowmelt and runoff reduced visibility to nearly zero and prevented use of the underwater camera.



**FIGURE 3-3: UNDERWATER VIDEO CAMERA SYSTEM.**

**TABLE 3-3: UNDERWATER VIDEO CAMERA DATES AND LOCATIONS.**

Camera Location	Date	Habitat	Water Depth	Ice/Snow Conditions	Film Time (minutes)	Fish Observed (Y/N)	Lighting Conditions	Notes
2003 confluence	1/24/2008	Run	4"	8" of ice covered by 1' of snow	N/A	No	Artificial Light	No video recording due to battery malfunction
W3-11B	2/20/2008	Pool	> 4'	8" of ice covered by 2' of snow	30	No	Artificial and UV Light	Located in channelized beaver pond (4' wide) with low flow (<.01 ft/s)
W3-10	2/21/2008	Riffle	3"	1" ice with 1.5' of snow	40	No	Artificial and Natural Light	Located in mainstem between beaver ponds
W3-4	2/21/2008	Run	8"	2" ice with 1.5' of snow	30	No	Artificial Light	
W3-10	3/26/2008	Riffle	2"	Open water pocket	30	Yes	Artificial and Natural Light	Juvenile coho observed
W3-6A	3/26/2008	Pool	> 5'	2.5' ice with 1' of snow	25	Yes	Artificial and UV Light	Juvenile coho observed Located in beaver pond
W2-7	3/27/2008	Run	1'	3" ice with 2' of snow	30	No	Artificial and UV Light	
W4-3	3/27/2008	Riffle	6"	NR	32	No	Artificial and Natural Light	
W4-6	3/27/2008	Riffle	6"	3" ice with 4' of snow	32	No	Artificial and Natural Light	
W3-6A	3/27/2008	Run	7"	2" ice with 3' of snow	32	No	Artificial and UV Light	
W3-4	3/27/2008	Riffle	6"	2" ice with 2.5' of snow	40	Yes	Artificial and Natural Light	Juvenile coho observed
W3-1	3/28/2008	Riffle	6"	4" ice with 1' of snow	30	No	Artificial and Natural Light	Located 150' upstream from the Chuitna
W3-1	3/28/2008	Riffle	5"	3.5" ice with 1' of snow	30	No	Artificial and Natural Light	Located 20' upstream from the Chuitna
W3-10	4/23/2008	Run	7"	4" ice with 5' of snow	32	No	Artificial Light	
W3-14	4/23/2008	Riffle	4"	4" ice with 6' of snow	31	No	Artificial Light	
W3-6A	4/23/2008	Run	6"	2" ice with 5' of snow	30	Yes	Artificial Light	Juvenile coho observed
W3-11B	4/23/2008	Run	3.5'	3" ice with 5' of snow	35	No	Artificial Light	
W4-3	4/23/2008	Run	1.7'	1" ice with 5' of snow	30	No	Artificial and Natural Light	
W3-9	4/24/2008	Pool	10"	1" ice	30	No	Artificial and UV Light	Beaver pond habitat in lateral tributary
W3-6B	4/24/2008	Run	1.8'	2" ice with active overflow on top of ice	30	Yes	Artificial and Natural Light	Juvenile coho observed
W3-7	4/24/2008	Pool	1'	2" ice with 1' snow	30	No	Artificial Light	
W2-12	4/24/2008	Run	8"	1" ice with 4' of snow	24	No	Artificial Light	

### 3.4. VIE Fish Captured Subsequent to Winter Study

Subsequent to 2007/2008 winter fieldwork, an additional 19 VIE-tagged fish were recaptured by LGL Environmental Research Associates (LGL), 18 at the weir on stream 2003 and one at a Rotary Screw Trap near the mouth of the Chuitna (Appendix 2). Dates of recapture ranged from May 15 to July 10, 2008, but most fish (84%) were recaptured between June 19 and June 26, 2008. All of these additional recaptures, with one exception, were coho salmon greater than 98 mm TL, suggesting that they were emigrating smolts. The single exception was a juvenile coho salmon, 68 mm in length that was recaptured in a screw trap near the mouth of the Chuitna. It was originally marked at VIE segment "I" in stream 2003. This individual was near but below the threshold size of 70 to 80 mm for survival in saltwater (Sandercock 1991) which suggests it may have been displaced by high water and not voluntarily migrating. More information on recaptures subsequent to OASIS field work is provided in tabular form in Appendix 2.

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## 4. DISCUSSION

Cold and often unpredictable weather, thick ice covering streams, and deep snow make wintertime juvenile fish sampling and habitat analysis in Alaska challenging. Because such studies are not commonly undertaken there is scarce literature available as points of comparison for this study or to provide a framework for discussions of the subject of the location, movement and habitat use by stream fish in Southcentral Alaska in winter. Researchers are forced to look southward (Southeastern Alaska, British Columbia, Canada, Washington State and Oregon) to locate winter habitat preferences for the species and apply knowledge gained from these research programs to more northerly Alaskan waters where appropriate.

The presence of ice on streams and ponds has a large impact on winter habitat preference particularly in northern latitudes. For instance, in some cases juvenile coho salmon overwintering in side channels impounded by beaver dams had higher rates of overwinter survival than juvenile coho salmon overwintering in side channels without beaver dams (Bustard and Narver 1975; Swales et al. 1986). However, beaver ponds that become ice-covered are likely to contain little dissolved oxygen and coho salmon juveniles may necessarily avoid these areas (Ruggerone 2000). Fry and parr are known to conceal themselves in substrate interstices and may move only to avoid ice crystals (Swales et al. 1986; Bustard 1986) or possibly to forage close to breakup when their stored energy reserves are nearing depletion (Enders et al. 2007). While winter juvenile salmonid movement in the southern portions of their range may be stimulated by freshets and floods, in the northern portion of their range, movement is more likely to be an adaptive response to avoid the effect of severe icing and low temperatures (Swales et al. 1988).

There was no change in the mean total length of fish captured throughout the winter (Table 4-1). The lack of change in mean length, coupled with the fact that sparse movement was detected, suggests that the coho salmon juveniles in the study were not actively foraging in the winter months. Anecdotal observations of poor body condition (weight loss) of captured fish in late winter partially substantiate this assertion and may be linked to immobility. Other research has suggested that the ability of juvenile coho salmon to move into preferred winter habitat may be dependent on body size and condition at the onset of winter (Giannico and Healey 1998). Larger size can help fish successfully compete for food resources or refuge space and better avoid or withstand physical stressors (Ebersole et al. 2006). Large body size may also convey higher overwinter survival rates (Ebersole et al. 2006; Giannico and Healey 1998). The direction (i.e. upstream or downstream) of fall migration, if any, may also have implications for both survival and body size. The upstream movement of coho salmon juveniles into tributaries was theorized to enhance survival by Ebersole et al. 2006. In another study utilizing artificial channels, fry that moved upstream tended to stay in the stream longer before smolting (Ruggles 1966). Upstream migrants averaged 14 mm

longer at emigration than smolts that had spent their entire lives in mainstem rivers (Skeesick 1970).

**TABLE 4-1: LENGTH AND AGE ESTIMATES OF ALL CAPTURED AND RECAPTURED JUVENILE COHO SALMON BASED ON LENGTH-AGE RELATIONSHIP FOR COHO SALMON (ERT 1983). TOTAL LENGTH SIZE RANGE PROVIDED FOR DOLLY VARDEN.**

	Total Number of Fish	Mean TL (mm)	Number of Age 0 fish*	Number of Age 1 fish*	Number of Age 2 fish*	TL Size Range for DV (mm)
Tagged DV	125	110.00	not analyzed	not analyzed	not analyzed	65-174mm
DV Recaptures	6	103.00	not analyzed	not analyzed	not analyzed	83-129mm
All DV Captures (tagged and untagged) During Recapture Sampling	137	105.20				50-153mm
Tagged Coho	1,907	72.90	1,109	789	9	
Coho Recaptures	82	74.70	39	43	0	
ALL Coho Captures (Tagged and Untagged) During Recapture Sampling	2,198	73.10	1,158	1,030	10	
Coho Recaptures Which Moved at least 200 Meters**	12	76.70	5	7	0	
Coho Recaptures by LGL***	19	108.50	0	1	18	

TL: Total Length

DV: Dolly Varden

\*Age estimate based on length frequency analysis from 2007 Annual Report

\*\*winter movement Oct. 2007 to May 2008

\*\*\*Recaptures subsequent to OASIS fieldwork

In more temperate climates individual fish may have more options in terms of undertaking the risk of moving to a new location before the onset of winter. The benefit is increased fitness through a higher growth rate by moving to an area that is sheltered from dewatering and flow extremes and has ample cover and food resources. The discharge of Chuitna tributary stream 2003 remained stable throughout the winter (RTi 2007) so theoretically there was less of a need or incentive for moving into more sheltered habitats. Indeed, the controlling factor in the limited movement patterns OASIS observed in VIE marked fish may be the flow regime of the Chuitna River tributaries. Summer flows were sustained from May through October with a high water period in the spring as a result of snow melt runoff and ice thawing, and intermittent high water periods in the fall coinciding with increased seasonal precipitation. The winter flow regime reflected base flow conditions (RTi 2007) because nearly all winter precipitation in the Chuitna River basin is in the form of snow. Despite the Chuitna River's close proximity to the tidal waters of Cook Inlet, conditions more closely match interior streams of British Columbia as opposed to Oregon coastal streams. Similarities in fish behavior and movement pattern also exist between tributary stream 2003 and some interior streams of British Columbia i.e. fish use the same habitat where they are found in October, throughout the winter and in the spring, coinciding with snowmelt and attendant high water, juvenile coho salmon disperse into summer rearing habitat, including ponds and other off-channel habitats, which may only be accessible during periods of high water.

Months of low CPUE late in the winter (March, April and May) may be attributed to three possible source categories. The first is fish behavior. Juvenile coho salmon may have been inactive, hiding in vegetative cover or demersally in substrate interstices as a means of conserving their energy resources.

Second is gear-related sampling bias. An inherent drawback to passive capture techniques such as minnow trapping is that they are subject to reduced trapping efficiency due to varying properties of the physical environment such as water temperature and water level (Murphy and Willis 1996). In addition, fish must be mobile, to some extent, in order to be captured inside a minnow trap. As water temperatures decreased through mid and late winter fish became physiologically stressed and presumably less active. Consequently, they were less susceptible to passive capture techniques such as minnow trapping.

Third is winter mortality. While no dead fish were observed and no effort was made to quantify mortality, coho salmon juveniles appeared to be in poor body condition in March and April based on anecdotal information. During sampling in May, after stream ice had melted, overall body condition was observed to improve markedly suggesting better food availability and a resumption of active foraging.

Based upon visual observations by OASIS biologists, anadromous Dolly Varden were present in the Chuitna River tributaries during summer (June-August) but left the system to overwinter in unknown locations with the cessation of coho salmon spawning. This was corroborated by an inability to capture Dolly Varden over 23 cm TL either by angling or hoop nets in September, 2007. While there are many lakes in the Chuitna River drainage, the system is functionally a non-lake system in regard to Dolly Varden overwintering in that there are no "headwater" lakes of sufficient depth to provide overwintering habitat for anadromous Dolly Varden populations (pers. comm. F. DeCicco). The non-anadromous form, however, was present throughout streams 2002, 2003, and 2004, though not as great in number as juvenile coho salmon. The evidence suggests a non-anadromous population of Dolly Varden that may be one of two forms: stream resident or lake resident (rare).

Bramblett et al. (2002) reported that Dolly Varden CPUE was significantly and consistently higher in tributaries compared to mainstream sites. This suggests overwintering conditions may be more favorable for Dolly Varden in tributary systems such as stream 2003 than in larger rivers such as the Chuitna. Six percent of the total number of fish tagged were Dolly Varden. Subsequently 6% of recaptured tagged fish were Dolly Varden suggesting that there was no significant movement of Dolly Varden out of stream 2003 either for smolting or for migration to other potential winter habitat.

Underwater observation by camera can be a cost effective method for acquiring information on fish distribution, density and behavior (Murphy and Willis 1996). Underwater observation by camera is a viable option that is unlikely to significantly disrupt behavior or induce stress which is especially important when studying sensitive or endangered species or any species during times of stress (such as overwintering). Likewise a camera may be suitable in habitats that are too shallow to be sampled easily

through means such as minnow traps (Murphy and Willis 1996). The efficacy of using underwater video cameras during winter is limited by effects of cold on batteries, light penetration under water and difficulties obtaining useful data (e.g., species ID, presence of tags, length, and relative condition).

Underwater camera surveys collected under-ice images of juvenile coho salmon in all three identified habitat types (riffle, run, pool) in stream 2003, including under-ice images in riffle habitat too shallow to set minnow traps. Riffle habitat presented especially difficult conditions to minnow trap in winter because of low water levels (traps need approximately 10 cm of water to allow fish access) and ice cover. Juvenile coho salmon were observed under the ice in two riffle, two run, and one pool habitat, but one site in particular is distinguished by shallow water under-ice and the observation of fish. On March 26 the camera was placed in less than 10 cm of water, under-ice, riffle habitat at site W3-10 and several juvenile coho salmon were quickly drawn to the bait from a downstream location. A small pool was located adjacent to the riffle approximately 30 meters downstream with a larger beaver pond complex further downstream. The observation suggests that juvenile fish in this drainage are willing to use riffle habitat in the winter and travel short distances between habitat types if a food source is detected. Grand (1999) suggests that a juvenile coho's individual willingness to accept risk while foraging will be negatively correlated with its body size, and although researchers were not able to determine the exact size of the foraging fish observed at W3-10, they appeared to be at least 60 mm in length. These camera observations document juvenile coho salmon moving between habitat types during the winter season, an event that was also documented, albeit rarely, by the VIE mark and recapture survey.

Underwater video surveys in the future may be used independently to verify the presence or absence of fish in areas that cannot be effectively trapped or areas in which traps have come up empty. Underwater video may also prove useful in studying the behavioral responses of fishes to manmade channel alterations during restoration or mitigation activities. Underwater video camera surveys, as an accompaniment to winter minnow trapping, provided real-time observations of juvenile coho salmon moving between habitat types in stream 2003, in both an upstream and downstream direction, during the winter of 2008 (see DVD provided in Appendix 3).

Based on the results of winter sampling OASIS concludes that juvenile coho salmon and small resident Dolly Varden utilize habitat in Chuitna River tributary stream 2003 during fall (September-October) and throughout the winter from freeze-up (November) until break-up (May). Bustard (1986), similarly observed "no net change" in coho numbers during trapping in the fall before ice up and again in the spring, suggesting that most juvenile coho salmon remained in the vicinity of rearing areas used in late October, throughout the winter. Juvenile coho salmon were observed wintering in large channel habitat and relied less on beaver dammed ponds than has been documented in other studies conducted in more southerly portions of their range (Bustard and Narver 1975; Swales et al. 1986; Pollock et al. 2004). While largely speculative, physiological barriers (i.e. limited energy reserves and associated metabolic stress) and physical obstacles

(i.e. ice, cold water), presented by winter conditions may discourage the type of longer range movement, and movement between habitat types, documented for these species in other portions of their range.

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## **APPENDIX 1**

### **Winter Fish Movement Table**

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### WINTER FISH MOVEMENT

Date	Tag Code	Distance (m)	Total Fish	Coho	Coho CPUE	Dolly Varden	DV CPUE	Tag Site	Recapture Site	Habitat at Tag Site	Habitat at Recapture Site
10/24/2007	LER	0	10	9	4.05	1	0.50	E	E_ACT	sm channel	sm channel
11/27/2007	REO	+200	7	7	3.50	0	-	D	D_4	lg channel	lg channel
12/18/2008	LEO	0	10	9	4.45	1	0.50	A	A_ACT	lg channel	lg channel
12/19/2008	RER	-1000 (approx)	2	1	0.28	1	0.28	I	A_4	lg channel	lg channel
1/22/2008	LER	0	18	18	10.05	0	-	E	E_ACT	sm channel	sm channel
1/23/2008	LEY	0	3	3	1.70	0	-	B	D_1	lg channel	lg channel
1/23/2008	REO	0	10	10	5.09	0	-	D	D_ACT	lg channel	lg channel
1/24/2008	LEO	0	1	1	0.53	0	-	A	A_ACT	lg channel	lg channel
2/19/2008	LEO	+1,000 (approx)	1	1	0.64	0	-	A	D_ACT	lg channel	lg channel
2/19/2008	REO	0	13	13	8.95	0	-	D	D_ACT	lg channel	lg channel
2/19/2008	LER	0	1	1	0.60	0	-	E	E_ACT	sm channel	sm channel
2/20/2008	RER	0	1	1	0.59	0	-	I	A_4	lg channel	lg channel
2/20/2008	RER	-800 (approx)	1	1	0.60	0	-	I	A_ACT	lg channel	lg channel
3/25/2008	LEY	0	1	1	0.54	0	-	B	D_1	lg channel	lg channel
3/25/2008	LER	-200	1	0	-	1	0.55	E	E_3	sm channel	sm channel
4/22/2008	REO	0	3	3	3.26	0	-	D	D_ACT	lg channel	lg channel
4/22/2008	REO	-200	1	1	1.09	0	-	D	D_3	lg channel	b. pond
4/22/2008	LER	-1,000	1	1	1.09	0	-	E	D_3	sm channel	b. pond
4/22/2008	LER	-200	1	0	-	1	1.02	E	E_3	sm channel	sm channel
5/15/2008	LER	0	1	1	1.01	0	-	E	E_ACT	sm channel	sm channel
5/15/2008	LER	-400	1	0	-	1	1.01	E	E_2	sm channel	sm channel

sm channel: small channel

lg channel: large channel

b. pond: beaver pond

Note: Tag Site B coincides with the location of Recapture Station D\_1

LER = Left Eye Red

REO = Right Eye Orange

LEO = Left Eye Orange

RER = Right Eye Red

LEY = Left Eye Yellow

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## **APPENDIX 2**

**VIE Tagged Juvenile Coho Salmon Recaptured Subsequent to OASIS Field  
Studies by LGL Environmental Research Associates**

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**VIE TAGGED JUVENILE COHO SALMON RECAPTURED SUBSEQUENT TO OASIS FIELD STUDIES  
BY LGL ENVIRONMENTAL RESEARCH ASSOCIATES**

Recapture Location	Recapture Date	Tag site	Total distance moved (km)	Location	Color	Total Length (mm)
RST2	5/15/2008	I	25.73	Right Eye / Anal Fin	Red/Yellow	68
Weir 3	6/19/2008	J	11.88	Anal Fin	Orange	111
Weir 3	6/20/2008	A	9.88	Left Eye	Orange	106
Weir 3	6/20/2008	A	9.88	Left Eye	Orange	105
Weir 3	6/20/2008	D	13.45	Right Eye	Orange	100
Weir 3	6/21/2008	J	11.88	Anal Fin	Orange	118
Weir 3	6/21/2008	A	9.88	Left Eye	Orange	111
Weir 3	6/21/2008	D	13.45	Right Eye	Orange	121
Weir 3	6/23/2008	A	9.88	Left Eye	Orange	117
Weir 3	6/23/2008	A	9.88	Left Eye	Orange	108
Weir 3	6/24/2008	A	9.88	Left Eye	Orange	116
Weir 3	6/24/2008	A	9.88	Left Eye	Orange	101
Weir 3	6/24/2008	H	15.22	Anal Fin	Yellow	113
Weir 3	6/24/2008	J	11.88	Anal Fin	Orange	119
Weir 3	6/24/2008	D	13.45	Right Eye	Orange	108
Weir 3	6/26/2008	D	13.45	Right Eye	Orange	108
Weir 3	6/26/2008	D	13.45	Right Eye	Orange	101
Weir 3	6/30/2008	D	13.45	Right Eye	Orange	96
Weir 3	7/10/2008	A	9.88	Left Eye	Orange	135

RST: Rotary screw trap #2, located near the mouth of the Chuitna

Weir 3: Weir located in the lower reaches of Stream 2003

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## **APPENDIX 3**

### **Underwater Video Recording DVD**

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