A 2012 Pilot Study Evaluating Juvenile Salmon Use of Knik Arm Estuaries

Prepared For:

National Fish Habitat Plan
Mat-Su Salmon Partnership

ARRI
Aquatic Restoration & Research Institute

Aquatic Restoration & Research Institute
Leslie R. Jensen, Jeffrey C. Davis, and Gay A. Davis
P.O. Box 923, Talkeetna AK, 99676

April 2013

Blank Page

Table of Contents

Summary

Estuaries can provide important rearing habitat for juvenile salmon as they transition from freshwater to marine environments. Estuarine habitats in Cottonwood Creek, Wasilla Creek/Palmer Slough, and O'Brien Creek were surveyed for fish presence and water quality during large tidal changes in July of 2012. The best approach we found to access these locations was to boat down from the nearest road crossing. Only main channel habitat types were present within the sampling areas. All sampling reaches showed a general trend of increasing turbidity, conductance, and salinity and decreasing vegetation cover in a downstream direction. Fish sampling was conducted with 1/8-inch mesh beach seines, sampled before tidal influx and at high tide slack water. Fish sampling was most effective using a combination of seine hauls deployed from a raft or canoe and baited minnow traps. Juvenile salmonids captured at these locations included coho salmon, chum salmon, sockeye salmon, and rainbow trout. All salmon captured in Cottonwood Creek were likely age 0, whereas salmon captured in O'Brien Creek showed a range of sizes and ages. No salmonids were captured in Palmer Slough. Seine hauls also captured some unidentified marine crustaceans at high tide, showing the importance of tidal influx to prey availability in these habitats.

Introduction

Estuaries are used by juvenile salmon as migration pathways, temporary feeding and refuge areas, and for osmoregulation. Pink salmon use estuaries mostly as a neutral pathway, whereas sockeye, coho, chum, and Chinook salmon all spend some amount of time feeding or adjusting to salinity (Chamberlin 2011; Simenstad et al. 1982; Healy 1982). Chinook and chum generally spend the most time feeding in estuaries, leaving freshwater by early summer and rearing in estuarine habitats sometimes until late fall (Dunford 1975).

Estuaries may provide a temporary rearing habitat for juvenile anadromous fish with more food availability than in freshwater, coupled with decreased predator pressure (See Review by MacDonald et al. 1988). Food sources in estuaries include both riverine and marine sources, through discharge and tidal influx. This region of potentially high food abundance could lead to increased growth of juvenile salmon in estuaries, as compared to freshwater rearing. One study in Southeast Alaska found that sockeye salmon rearing in estuaries for three months showed growth roughly equivalent to an entire year's worth of growth in freshwater (Heifetz et al. 1989). Additionally, some juvenile salmon in these

habitats actively seek out high densities of each food source to maximize growth. Schools of juvenile chum have been observed moving upstream at low tide to access riverine prey, and then moving downstream at high tide to access the incoming marine prey (Mason 1974).

Studies in Northern Cook inlet found all five species of Pacific salmon in both shoreline and open water areas, with higher abundances near large river mouths (Moulton 1997). Chinook and chum salmon densities within Cook Inlet were inversely correlated with salinities, indicating they were still transitioning from freshwater and using river mouths as rearing areas during the entire sampling period of June through September.

Knik Arm estuaries have also been specifically described as providing critical habitat for migrating juvenile salmon. Prevel-Ramos (2012) found that collectively, research in the Knik Arm has shown that these estuarine habitats provide a refuge from predators, a transitional area for osmoregulation, and a place to feed. Juvenile salmon collectively are the most dominant taxon present throughout the summer and fall in Knik Arm shoreline habitats, but only coho and Chinook salmon seem able to orient and remain along shoreline areas. The smaller species were more likely to be entrained in the strong currents and carried out of the Arm (Houghton et al. 2005). Schooling and visual feeding behaviors are likely limited by high turbidities in Knik Arm, but growth has been observed and many fish captured had very full stomachs (Houton et al. 2005).

All previous studies on salmon distribution in the Knik Arm have focused on the main water body of the Knik Arm. No sampling efforts have been conducted within the mouths of tributaries, at the interchange between freshwater and estuarine water. The objectives of this study were to: 1) identify and map estuarine habitat types in the Cottonwood Creek, Wasilla Creek/Palmer Slough, and O'Brien Creek estuaries; 2) locate access points to sampling sites; 3) test and develop methods for sampling within different habitat types; and 4) measure relative abundances of juvenile salmon in different habitat types, if present.

Methods

The Knik Arm is a shallow glacial estuary located in the northern edge of Cook Inlet (Figure 1). This estuary is characterized by extreme physical habitats of large tidal ranges, strong currents, and high glacial and coastal sediment inputs. The average tidal range within Knik Arm is 7.6 meters with maximum ranges of up to 11.9 meters per tidal cycle. (Britch 1976). The strong currents and high sediment inputs result in very high turbidities, averaging >250 NTU with point measures in excess of 1100 NTU (Houghton et al. 2005).
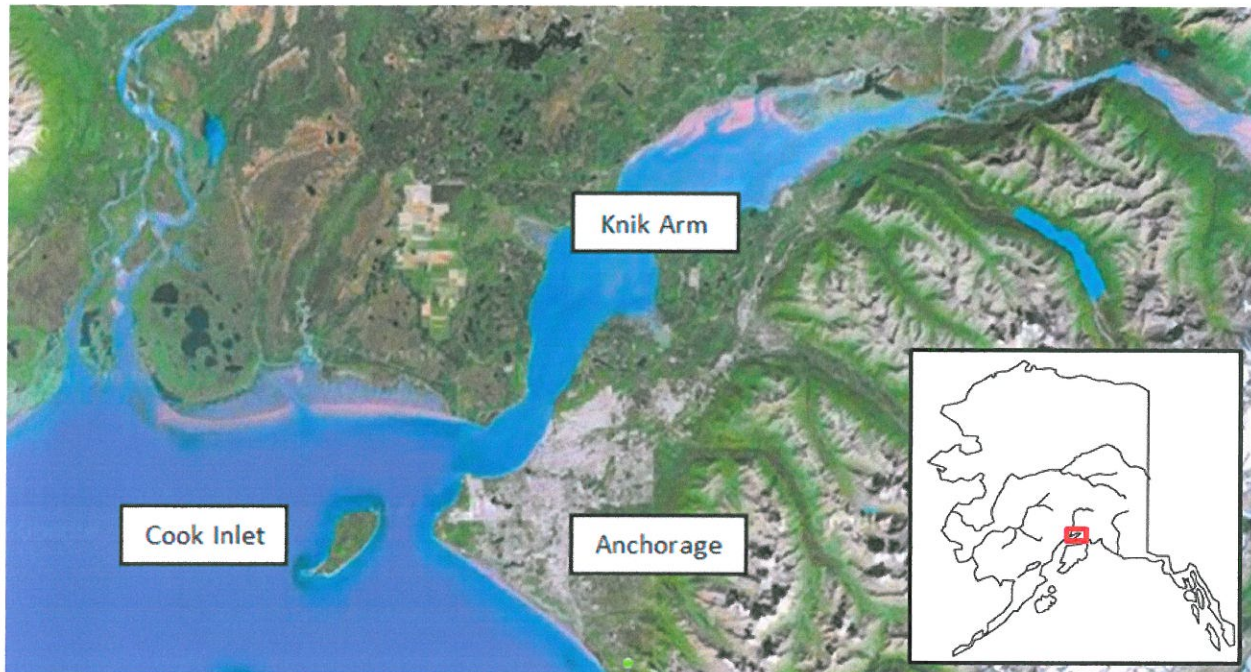
Figure 1. Map of the Knik Arm of Cook Inlet in Southcentral Alaska.

The sampling area selected for habitat surveys and fish and water chemistry sampling efforts included O'Brien Creek, Cottonwood Creek, and Palmer Slough estuarine areas (Figure 2). Using aerial imagery and USGS Topo! Maps, potential locations for tidal ponds, sloughs, and main channels were identified within the sampling areas. These areas were surveyed in June to verify habitat types and assess feasibility for fish and water quality sampling. We canoed down Palmer Slough and hiked up what we believe to be the mouth of Wasilla Creek, searching for connections to the ponds identified from maps and aerial imagery. We also attempted to hike to Palmer Slough from upstream of Wasilla Creek over a floating bog, but we had to abandon this approach due to concerns about safety and level of effort required by this approach. Only main channel habitat types were identified during these survey efforts, so sampling locations within each area were limited to this single habitat type.

Figure 2. Sampling areas for water quality and fish sampling from left to right: O'Brien Creek, Cottonwood Creek, Palmer Slough Downstream, and Palmer Slough Upstream. O'Brien Creek was sampled on July 24, Cottonwood Creek on July 23, and both Palmer Slough sites were sampled on July 10, 2012.

Initial sampling efforts to test methods were conducted during seasonally low high tides, due to concerns about safety with rapid stage and velocity changes within the sampling locations. Sampling less extreme conditions allowed us to test different sampling methods and access points without the added difficulty of large tidal fluctuations. After methods and access points were decided upon, the selected sites were sampled for water quality and juvenile fish during seasonally high, high tides in mid-July.
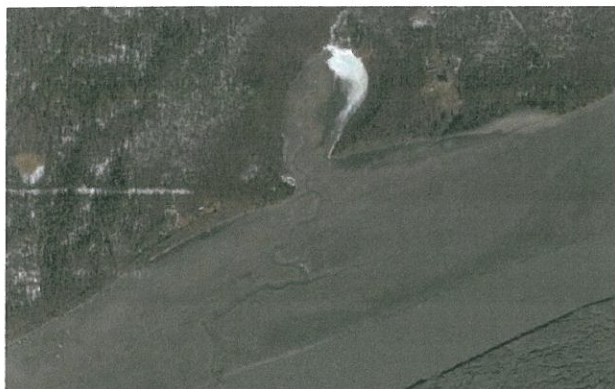
Figure 3. O'Brien Creek sampling site. Stream length from forest edge (top) to Knik Arm open water (bottom) is approximately 1/3 miles.

Sampling efforts were conducted at each location before the incoming tide and at slackwater associated with high tides in mid- to late-July. O'Brien Creek was sampled along the entire length from forested edge to Knik Arm open water estuary (Figure 3). This stream reach is approximately 1/3 miles in length and was sampled during a high tide of 28.82 feet, on July 24, 2012. Cottonwood Creek was sampled along a 0.5 mile reach with the upstream edge at the

4

Palmer Hay Flats access road (Spring Creek)(Figure 4). This area was sampled on July 23 during a high tide of 29.80 feet. All tidal measurements were those reported for Anchorage, Alaska. Palmer Slough was sampled at two locations approximately 2.5 river miles from each other (Figure 5). Both locations were sampled on July 10, 2012 during a high tide of 25.09 feet.

Figure 4. Cottonwood Creek sampling area. Sampling reach is approximately 0.5 miles in length.

Figure 5. Palmer Slough sampling sites. Sampling site #2 (left) is approximately 2.5 miles downstream of sampling site #1 (right). Each sampling reach is 100 m in length.

Juvenile fish were sampled with 1/8-inch mesh beach seines (40-ft length), deployed from a raft or canoe, moving in the direction of water flow (Photograph 1). At each location, at least three beach seine hauls were conducted along the length of the sampling reach immediately before the incoming tide and again in the slack water associated with high tide. Each seine haul sampled 40-50 feet of the stream bank.

Photograph 1. Deploying a beach seine from a raft in Palmer Slough, July 10, 2012.

Beach seine sampling was limited by the channel and bank conditions within each sampling reach. The silt/mud substrate that comprised most of the stream banks and channel could not be accessed safely by foot, especially water-saturated banks or steep banks. Locations for seine hauls were selected based on foot accessibility to the water's edge, avoiding silt/mud areas that we were likely to sink into. The mud also affected haul success, as mud sometimes clogged or snagged the net (Photograph 2). Hauls that were not pulled smoothly across were thrown out of results due to likelihood of fish loss.

Photograph 2. Beach seines frequently became clogged with mud while sampling estuarine habitats.

Supplemental fish sampling was tested at the O'Brien Creek location with ten quarter-inch mesh gee minnow traps (Mephis Net and Twine) baited with salmon roe enclosed in perforated whirl-pak bags. Minnow traps were used to sample the mostly freshwater-influenced upstream section of the sampling reach. Minnow traps were placed within backwater or slow moving water areas and fished for an interval of 1.5 hours. Five of the traps were in a clear, all freshwater portion of the stream and five traps were in a more turbid and mild estuarine environment. Areas with more estuarine influence could not be sampled with minnow traps due to large water velocity changes at the incoming tide which could harm any captured fish. All fish captured with beach seines or minnow traps were identified to species, and salmonids were measured to fork length.

Water quality values were measured within each sampling reach during high tide slack water. Measurements included dissolved oxygen (YSI 550A), turbidity (Lamotte TC-3000e) pH, specific conductivity, and salinity (YSI 63). In O'Brien Creek, water sampling was conducted at two locations that coincided with the most upstream minnow trap and the most upstream seine haul. The upstream minnow trap was just downstream of the completely freshwater wooded stream section, and the most upstream seine haul was located at the mid-point of the sampling reach. In Cottonwood Creek, water sampling was conducted at the upstream edge of the sampling reach two hours before high tide and again at the downstream edge of the reach at high tide, immediately prior to fish sampling each time period. At Palmer Slough, water quality measurements were collected only once at each of the two sites, during high tide slack water. We additionally measured cross-sectional depths at both sites in conjunction with water chemistry measurements.

Results

Initial surveys to map habitat types of main channels, side sloughs, and tidal wetlands only identified main channels within the sampling area. Although high tides increased available habitat area within main channels, through increased width and depth, it did not create new access routes to wetland ponds or side sloughs. These habitat types were not present in the surveyed areas, and there were no channels for connecting estuarine water to freshwater habitats, except at stream mouths.

Accessing sampling sites was best achieved by rafting or canoeing from the nearest road or property down to the sampling location (Photograph 3). Both O'Brien and Cottonwood creeks sampling locations were very near to public or private roads and could be easily accessed by foot and canoe. The Palmer Slough location was more than five river miles from the nearest upstream road and more than one mile by land to the nearest road crossing. Reaching the site by foot was difficult and assessed to be

too unsafe because most of the distance was across floating vegetation mats. The best approach to access Palmer Slough was by rafting down from the nearest boat launch with an outboard jet motor. This method allowed for travel through shallow and/or thickly vegetated areas at low tide but was less maneuverable than canoes for setting beach seines at the sampling site.

Photograph 3. Combination of hiking and boating to access and sample selected stream reaches.

Palmer Slough had distinct habitat changes from the upstream sampling site #1 downstream approximately 2.5 miles to sampling site #2. Sampling site #1 contained submerged and overhanging vegetation along more than half of the shoreline length, had a wetted width at high tide of 8.967m and a total width of 11.700m. The downstream site (#2) contained no submerged or overhanging vegetation and a wider wetted width of 9.467m and total width of 16.700m. Depth profiles for each site are listed in Table 1. This downstream site was entirely composed of a mud channel bottom with mud banks (Photograph 4). Palmer Slough had increasing turbidity and specific conductance from Sampling Reach #1 to Sampling Reach #2. Values ranged from 11.14 NTU and 366.8 μS/cm at the upstream site up to 115.6 NTU and 411.5 μS/cm at the downstream site. Both locations had salinities of 0.2 ppt during sampling.

Table 1. Depth profile of Palmer Slough sampling sites, measured at high tide slack water. Distances are measured from left water's edge.

| Sampling Site #1		Sampling Site #2	
Distance (m)	Depth (m)	Distance (m)	Depth (m)
0	0.055	0	0.08
2.3	0.885	0.9	1.20
4.6	1.015	2.8	1.22
6.4	0.955	4.9	0.51
9.2	0.055	7.1	0

The only fish captured at either sampling reach in Palmer Slough were stickleback. We captured a total of 85 unidentified stickleback at Sampling Reach #1, for a CPUE of 28.33 fish/haul. Additional stickleback smaller than the 1/8-inch mesh size of the net were observed at this location. At Sampling Reach #2, we captured a total of 19 unidentified stickleback in three beach seine hauls for a CPUE of 6.33 fish/haul.
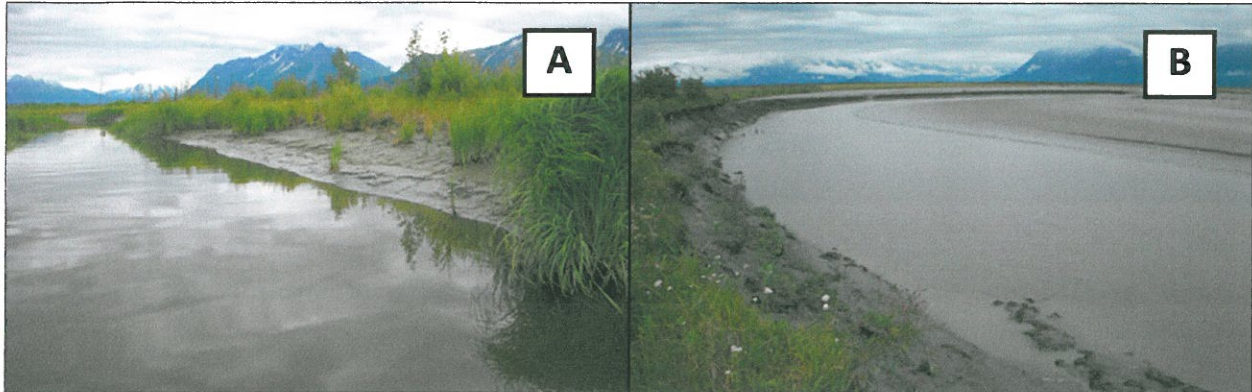

Photograph 4. Palmer Slough at (A) Sampling Reach #1 and (B) Sampling Reach #2. The upstream reach (A) has less turbid and saline water, with more shoreline vegetation.

Cottonwood Creek had moderate habitat changes along the 0.5 mile sampling reach, with increasing width and decreasing vegetation cover downstream (Photograph 5). Before the incoming tide, turbidity was 110.83 NTU, specific conductance was 243.6 μS/cm, and salinity was 0.1 ppt. At high tide, specific conductivity increased to 1132 μS/cm, and salinity increased to 0.6 ppt.

We were able to conduct five beach seine hauls along the sampling reach before the tide came in and seven hauls at high tide. We captured 1 salmonid/haul and a total of 2.2 fish/haul during the first sampling event and 0.29 salmonids/haul and 1.57 fish/haul during the second sampling event. Salmonids captured included coho salmon, chum salmon, sockeye salmon, and rainbow trout. The salmon were all likely young of year, with fork lengths ranging from 43-56 mm. Non-salmonid species captured were blackfish, ninespine and threespine stickleback, and an unidentified sculpin. Additionally, we captured some unidentified marine crustaceans at high tide, showing the influx of prey with tidal changes (Photograph 6).
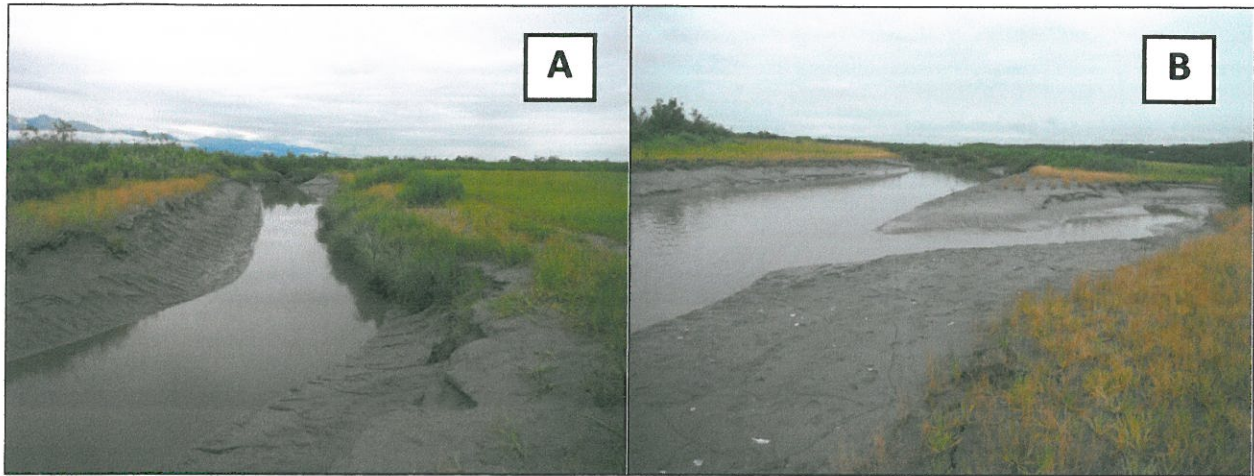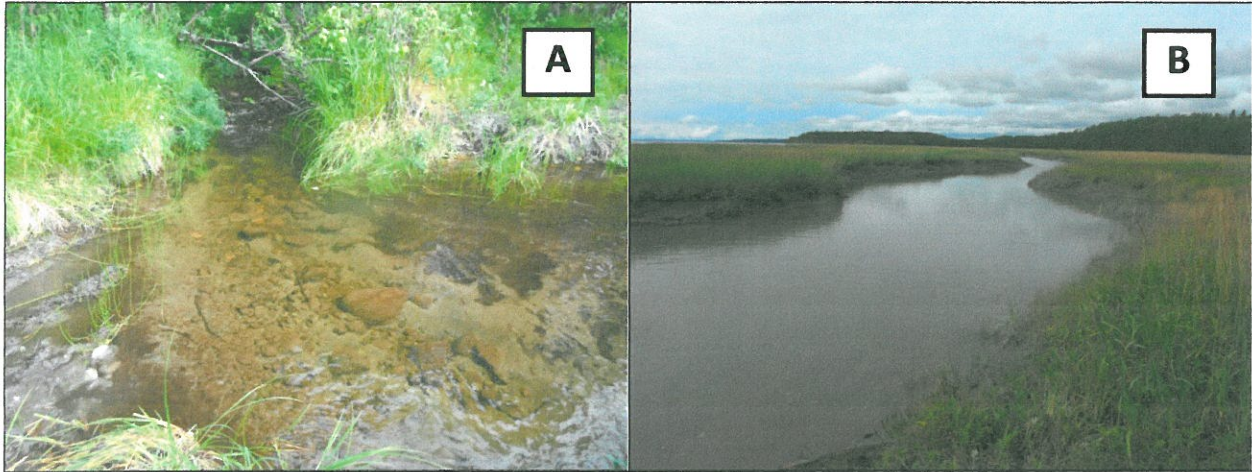
Photograph 5. Cottonwood Creek at (A) the upstream edge and (B) the downstream edge of the sampling reach. The reach gradually increased in width and turbidity and decreased in shoreline vegetation in a downstream direction.
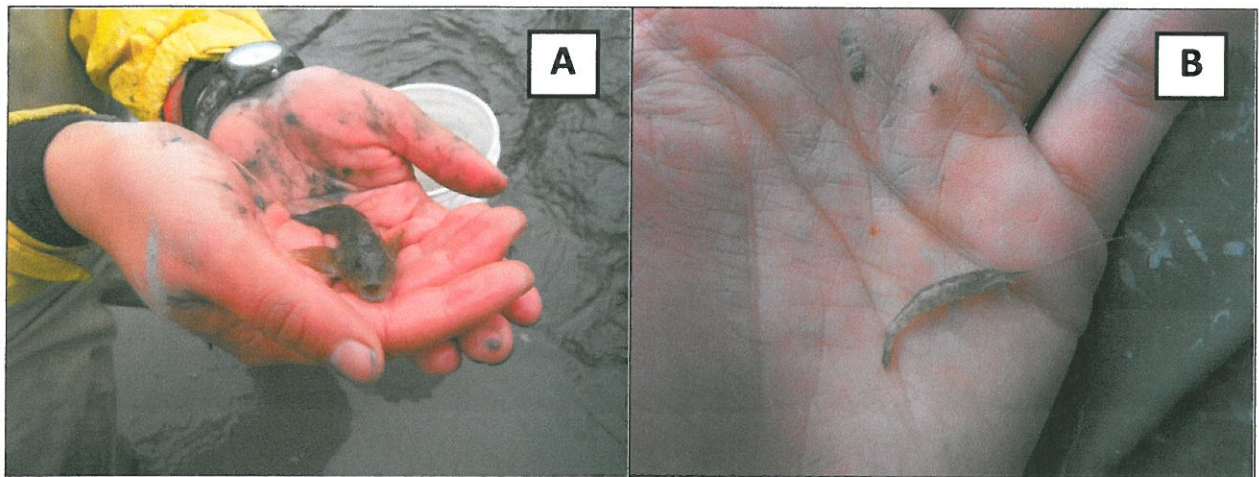
Photograph 6. Selected non-salmonid catches in beach seine hauls in Cottonwood Creek. A) Unidentified sculpin *Cottid spp.* B) Unidentified marine crustacean. Additional species captured included burbot, threespine stickleback, and ninespine stickleback.

The O'Brien Creek estuarine-influenced reach was much shorter in length than the other streams sampled, with a total stream length of approximately 1/3 miles from completely freshwater to the Knik Arm open water estuary. The upstream edge of the sampling reach was a narrow clear water area that transitioned into a wider channel with vegetation cover only available at high tide (Photograph 7). The entire reach was sampled for water chemistry, with rapidly increasing values along the length of the sampling reach. Turbidity increased from 7.74-131 NTU, specific conductivity increased from 333-4600 µS/cm and salinity increased from 0.2-2.5 ppt.

We captured three coho salmon with the minnow traps for a CPUE of 0.6 fish/trap, as well as one coho salmon and eleven threespine and ninespine stickleback in beach seine hauls for a CPUE of 2.4 fish/haul. All of the coho salmon were captured at the transition zone between freshwater and estuarine habitats, in the most downstream placed traps and the most upstream beach seine haul. Coho salmon fork lengths ranged from 50-102mm, showing a diversity of age classes present in this area.

Photograph 7. O'Brien Creek at (A) the upstream edge and (B) the downstream edge of the sampling reach. The upstream edge is categorized as a clear, narrow, mostly freshwater influenced habitat, and the downstream edge is categorized as a wide, turbid, mostly estuarine influenced habitat.

Discussion

The low numbers of fish caught in this estuary during mid-summer is consistent with previous studies of estuaries in the Knik Arm (Houghton et al. 2005). We attributed this trend of low numbers of fish in Knik Arm estuaries to water chemistry and an extreme habitat, as well as the timing of sampling events. Sampling occurred in mid- to late-July, when most juvenile salmon have likely already left the upper estuary for either the lower estuary or the marine environment (see review by Healey 1982). Future sampling during spring, when juvenile salmon estuarine use is predicted to peak, should give a more accurate picture of the importance and function of this estuarine habitat.

Water chemistry varied significantly within the sampling reach, with turbidity, conductivity, and salinity increasing rapidly downstream in each sampling site. This extreme change in habitat over a short distance can be very stressful for juvenile salmon rearing or acclimating to salt water. Additionally, the tidal changes in this area are also extreme, and create velocity fluctuations that may be too strong for small juvenile salmon to maintain positions within the upper estuary.

The 2013 sampling effort will again focus on sampling the transition zone between freshwater and estuarine water, which has the potential to be the most productive area, due to the combination of freshwater and marine food sources. It is unclear if turbidity and velocity fluctuations associated with tidal changes are too extreme for extended periods of juvenile salmon rearing. If this is true, these estuarine reaches may only be used as migration corridors and for salinity adjustment. Field sampling in 2013 will occur during the spring outmigration of salmon smolts, which occurs from April through June, depending on the species of interest.

The Knik Arm estuaries surveyed in this study are in pristine condition, lacking human development and modifications. A comparison of estuaries along the west coast found a strong relationship between pristine habitat and survival rates of subyearling Chinook salmon (Magnusson and Hilborn 2003). Chinook salmon in pristine estuaries had survival rates more than three times as high in pristine estuaries than in estuaries with modifications and development.

Although we did not capture many juvenile salmonids in 2012, we know that they have to at least pass through this habitat during their migration to the marine environment, if not rear here during spring and summer months. Maintained natural habitat conditions will help to minimize stress and maximize survival rates for these juvenile fishes.

Literature Cited

Britch, R. 1976. Tidal Currents in Knik Arm, Cook Inlet Alaska. MS Thesis, University of Alaska, Fairbanks, Alaska.

Chamberlin, J.W., A.N. Kagley, K.L. Fresh, and T.P. Quinn. 2011. Movements of Yearling Chinook Salmon during the First Summer in marine Waters of Hood Canal, Washington. Transactions of the American Fisheries Society 140(2): 429-439.

Dames and Moore. 1983. Knik Arm Crossing Project Technical Memorandum No. 15. Marine biological studies. Prepared for the U.S. Department of Transportation, Federal Highway Administration and the Alaska Department of Transportation and Public Facilities.

Dunford, W.E. 1975. Space and food utilization by salmoninds in marsh habitats of the Fraser River Estuary. M. Sc. Thesis, Dep. Zoology, Univ. British Columiba, Vancouver, B.C. 90 p.

Healey, M.C. 1982. Juvenile Pacific Salmon in Estuaries: The Life Support System, p. 315-341. In V.S. Kennedy [ed.] Estuarine Comparisons. Academic Press, Inc., New York, NY.

Heifetz, J., S.W. Johnson, K.V. Koski, and M.L. Murphy. 1989. Migration timing, size, and salinity tolerance of sea-type sockeye salmon (Oncorhynchus nerka) in an Alaskan estuary. Canadian Journal of Fisheries and Aquatic Sciences 46:633-637.

Houghton, J., Starkes, J., Chambers, M., and D. Ormerod. 2005. A marine Fish and Benthos Studies in the Knik Arm Anchorage, Alaska. Prepared for Knik Arm bridge and toll authority and HDR Alaska Inc. Prepared by Pentec Environmental.

MacDonald, J.S., C.D. Levings, C.D. McAllister, U.H.M. Fagerlund, and J.R. McBride. 1988. A Field Experiment to Test the Importance of Estuaries for Chinook Salmon (Oncohynchus tshawytscha) Survival: Short-term Results. Canadian Journal of Fisheries and Aquatic Sciences 45: 1366-1377.

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

Mason, J.C. 1974. Behavioral ecology of chum salmon fry (Oncorhynchus keta) in a small estuary. Journal of Fisheries Research Board of Canada. 31: 83-92.

Moulton, L.L. 1997. Early marine residence, growth and feeding by juvenile salmon in Northern Cook Inlet, Alaska. Alaska Fishery Research Bulletin 4: 2, 154-177.

Prevel-Ramos, A., Brady, J., and J. Houghton. 2012. Knik Arm Anadromous Fish Study Designs. U.S. Fish & Wildlife Service, Anchorage, AK.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function, p. 343-364. In V.S. Kennedy [ed.] Estuarine Comparisons. Academic Press, Inc., New York, NY.