

FINAL REPORT

Rainbow Smelt Spawning Survey

Kuskokwim River, Alaska - 2014

September 2014

Prepared for:

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EXECUTIVE SUMMARY

Donlin Gold, LLC (Donlin Gold) has proposed developing an open pit, hardrock gold mine in southwest Alaska, 10 miles north of the village of Crooked Creek on the Kuskokwim River (the project).

The U.S. Army Corps of Engineers (USACE) is the lead agency in the preparation of an Environmental Impact Statement (EIS) for the project. Potential and hypothetical impact concerns raised include rainbow smelt spawning habitat degradation or destruction as a result of propeller scour from barge traffic. Barge traffic in the study area is already ongoing, but the proposed project would result in an increase in the amount of barge traffic. A review of available data on rainbow smelt on the Kuskokwim River concluded that existing scientific data was limited and additional field work was required to better understand the species occurrence and spawning habitat. Collection of additional data was requested by the USACE. Data collected will be used by the USACE to assess the potential impacts of barging to this subsistence harvest resource.

The study used helicopter survey, dip net sampling, and sediment sampling with a pipe dredge to identify 1) the upstream extent of rainbow smelt movements, 2) characteristics of the spawning population, and 3) the distribution of eggs and associated spawning habitat characteristics.

In 2014, rainbow smelt moved rapidly upstream in the mainstem Kuskokwim River, arriving at Bethel on May 18 and arriving at Kalskag, or 184 river kilometers (km) (114 river miles), 4 days later. This rapid movement caused the migrating adult smelt to be available for harvest for only a short period of time, with each village having a day or two for harvesting before the migration passed upstream. The pattern of fishing indicated that the smelt moved upstream as a single school rather than multiple waves, because once the first wave passed all fishing ceased.

The egg deposition survey identified a rainbow smelt spawning area covering approximately 6.7 km (4 miles) of river channel just upstream from Upper Kalskag. The smelt spawned in this area between May 21 and 22. Spawning was in relatively deep water, primarily 1.5 to 3.0 meters (m) deep, with some as deep as 4.2 m, which afforded protection from both avian predators and the risk of eggs desiccating if flow decreased during the 2 to 3 week incubation. Spawning smelt also selected areas of high flow, with water velocities 0.75 to 1.25 m/sec (2.5 to 4.1 ft/sec), which assured a constant flow of well-oxygenated water. The spawning substrates consisted of well-armored cobble/gravel to mixed sand/gravel/cobble, which tend to be stable under most flow regimes except during extreme high flow events.

It was evident from working on the river, conducting depth transects and sampling sediment that the physical characteristics of spawning habitat observed in 2014 are in abundant supply in this portion of the river. The substrate composition, depths, velocities and channel structure selected during 2014 were commonly available, so the exact spawning location may show considerable annual variation

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1. INTRODUCTION

Donlin Gold, LLC (Donlin Gold) has proposed the development of an open pit, hardrock gold mine in southwest Alaska, 10 miles north of the village of Crooked Creek on the Kuskokwim River (the project). The U.S. Army Corps of Engineers (USACE) is the lead agency in the preparation of an Environmental Impact Statement (EIS) for the project. Potential and hypothetical impacts concerns raised include rainbow smelt spawning habitat degradation or destruction as a result from propeller scour from barge traffic. Barge traffic in the study area is already ongoing, but the proposed project would result in an increase in the amount of barge traffic. A review of available data on rainbow smelt in the Kuskokwim River concluded that existing scientific data was limited and additional field work was required to better understand the species occurrence and spawning habitat. Collection of additional data was requested by the USACE. Data collected will be used by the USACE to assess the potential impacts of barging to this subsistence harvest resource.

Rainbow smelt are a small anadromous fish, which reach a maximum size of about 300 millimeters (mm) (12 inches) that spawn in lower reaches of streams throughout much of the Bering, Chukchi and Beaufort seas. Rainbow smelt are harvested throughout much of their range when the populations are easily accessible. This accessibility is often limited to wintering areas, which tend to be in marine or brackish areas near river deltas, or during the spawning run. Spawning runs occur at or shortly after break-up as river water warms. The smelt ascend rivers in bands near the banks, which makes them susceptible to harvesting using dip nets. They typically do not migrate great distances, staying in lower portions of streams, but upstream from marine influence. In the Kuskokwim River, harvest by Bethel residents is concentrated between Napakiak and Kuskokuak Slough (Simon *et al.* 2007). In 2011 and 2012, peak upstream harvests were reported at Kwethluk and Akiachak, with high catches ending at Tuluksak (Shelden *et al.* 2014), although catch rates are still relatively high as far upstream as Kalskag (Figure 1). Coffing *et al.* (2001) report that 84% of the households in Akiachak use smelt as a subsistence resource.

In the Togiak River, just south of the Kuskokwim River, spawning occurred from late May to late June; peak spawning in 2007 was from May 28 to June 17 (Dion and Bromaghin 2008). Eggs hatch at around 21 days of incubation, depending on water temperature, and the larvae are carried downstream into the estuary, where they begin their marine residence. Coffing *et al.* (2001) report that subsistence smelt harvest in Akiachak occurred from late May to early June, which is consistent with the timing in the Togiak population. A similar timing was given by Brown *et al.* (2013) for smelt harvesting at Tuluksak, near the upstream limit of substantial smelt harvest, although limited smelt harvest has been reported as far upstream as Aniak (Sheldon *et al.* 2014). There was scant information on the Kuskokwim River smelt population itself other than the report that they are taken in the local subsistence harvest.

Information on the smelt spawning run would assist in the evaluation of potential impacts to their population from project operations. The study was designed to provide information regarding:

1. Timing of the spawning run.
2. Biological characteristics of smelt aggregations, including sex ratio and stage of maturity (*i.e.*, pre or post spawning).

3. Location and general extent of major identified spawning areas.
4. Physical characteristics of identified spawning areas.

The study focused on the area upstream and downstream of Kalskag, with additional information to be obtained from the area near Birch Tree Crossing. This study area was selected based on information provided by local resource users as communicated to Dave Cannon, Environmental Director, Native Village of Napaimute. Information from local sources indicated that the spawning run in most years usually ended in the vicinity of Kalskag, although there were reports of smelt being dip-netted in the vicinity of Aniak in some years.

2. METHODS

2.1. Aerial Survey

A helicopter-based aerial survey was scheduled to begin when rainbow smelt approached the Kalskag study region. The survey team mobilized when information was obtained from local observers that smelt had been observed in the lower river near Akiak and Tuluksak, and were progressing upriver to the study area near Kalskag. The aerial survey was used to identify concentrations of smelt, which provided information on upstream migration rates and likely spawning areas.

Observations to be recorded were:

1. Concentrations of gulls, which are known to accompany large aggregations of smelt.
2. Locations of dip netters actively fishing for smelt.
3. Visible aggregations of fish schools.
4. Stream habitat observations, particularly riffles and gravel bars.

Information from the aerial observations was relayed to the boat crew to allow them to begin biological sampling in a timely manner. The initial survey concentrated on identifying areas of smelt activity in or near the Kalskag study area, later efforts focused on the Birch Tree Crossing region.

2.2. In-River Net Sampling

In-river sample collection was initially conducted by a single boat-based team, with the aerial team joining the sampling program as a second team when aerial surveys were completed. Sampling sites were focused near high fish concentrations and/or harvesting areas identified from the aerial survey. Sampling for fish was by 60 centimeters (cm) (2 foot [ft]) diameter dip nets. The boat-based team consisted of a lead fisheries biologist and a support scientist.

Each dip net sampling event was documented as to location, set time, set duration, and catch composition. For dip netting at a single location, the start time, number of net sweeps, and end time constituted the measure of effort. All sampling resulting in no catch was treated as valid records. Water temperature, depth, velocity, and conductivity were recorded at each sampling location.

Smelt captured were measured for both fork length and total length to the nearest millimeter to allow comparison with other studies around the state. Sex and state of maturity were recorded and all captured smelt, except retained females, were returned to the water where caught. Females were retained from each sample to obtain gonadosomatic index (GSI), which is a measure of maturity. To obtain GSI, the fish was weighed to the nearest 0.1 gram, before and after the ovaries were removed. GSI was calculated as: $(\text{weight of ovaries})/(\text{weight of fish} - \text{weight of ovaries})$.

2.3. Sediment Sampling

Sampling for deposited rainbow smelt spawn began May 24 after it was evident that adult rainbow smelt had left the area. Initial tests were made with a Petite Ponar dredge, and Eckman dredge and a pipe

dredge. It was quickly evident that the sediment composition was not conducive to sampling with the Petite Ponar or Eckman dredges because an abundance of cobbles interfered with the dredge closing mechanisms, so the pipe dredge was used for the remainder of the study.

Areas to be sampled for sediments were identified from the aerial survey from visual observations of adult smelt distribution. A pipe dredge was used to sample sediments for both presence of smelt eggs and sediment size. The custom-made dredge was 40 cm long (16 inches), with a 15 cm diameter opening (6 inches) (see Photo Set 2). Pipe dredge sampling consisted of the following procedures:

1. A desired sample transect was identified based on depth and location within the river channel.
2. The pipe dredge was deployed as the boat drifted along a selected sample transect.
3. Minor course corrections were made along the transect to maintain a desired depth.
4. The dredge was retrieved after 30-60 m (100-200 ft) of drift, which was usually sufficient to provide an adequate sample in gravel/cobble substrate. In sandy areas, the dredge filled within 3-6 m (10-20 ft).
5. Samples were transported to the beach where the mixed substrate was reduced to the egg-bearing portion.

As with net sampling, water temperature, depth, velocity, and conductivity were recorded at each sampling location.

2.3.1. *Presence or Absence of Smelt Eggs*

Sample processing and detection of smelt eggs used methods recommended in Moulton and Pentilla (2000). The bulk egg samples obtained with the pipe dredge were processed to remove most of the sand/gravel/cobble and reduce the volume of the sample. Larger gravels and cobble were inspected for presence of eggs. Material retained by the 0.5 mm screen was processed for smelt eggs. This processing was done by washing the egg-bearing sand from the sediment sample and discarding the barren sediment. The egg-bearing material is lighter than the sand and gravel and will move upward during the washing process, allowing the eggs and attached sand grains to be skimmed from the surface of the material. The washing was conducted as follows:

- The 4.0, 2.0 and 0.5 mm screens were assembled on top of the wash bucket, with the larger mesh on top, the smaller mesh on the bottom.
- The sample label was removed and placed in an 8-ounce sample jar.
- The sample, or a workable portion, was placed on the top screen and thoroughly washed through the screen set with river water.
- Sediments from the top screens were discarded after being examined for eggs, only the material in the bottom (0.5 mm) screen was retained.
- The material retained in the 0.5 mm screen was dumped into a dishpan.
- Water was added until the material was covered by 2.5-5.0 cm of water.

- Water was swirled around the pan, adding rocking and bouncing motions to allow the eggs to migrate to the top of the sediment.
- After swirling for 1-2 minutes, the lighter fraction of material was worked to one corner of the pan. The lighter fraction was carefully dried out by tipping the pan so that the water drained away, then the lighter fraction was skimmed from the surface of the sand with the sample jar.
- The winnowing process was repeated two more times.
- The sample jar was filled with Stockard's Solution to preserve the eggs, then sealed securely and inverted carefully several times to ensure that the preservative reached all the eggs.
- Prior to shipping, the jar lids were taped shut with electrician's tape to prevent leakage.

2.3.2. *Sediment Composition*

Sediment composition was visually classified for 42 of the 54 sediment samples. Categories used for classifying were sand (0.250 to 1.00 mm), gravel (2.0 to 50 mm), and cobble (50 to 150 mm). As the samples were usually mixed substrate, the dominant class was listed first, followed in order by less dominant classes. The initial plan was to process the sediment samples volumetrically in the field, but this process was too time-consuming and it was decided to eliminate the sediment analysis and concentrate on mapping egg distribution.

2.3.3. *Laboratory Examination of Egg Samples*

Laboratory examination began with a further condensing of the sample. The winnowing process conducted in the field was repeated using a shallow tray to separate the eggs from the sand. Final separation was performed under a dissecting microscope at 10-20x, where the smelt eggs become quite visible. The number of eggs in each sample was direct counted.

2.4. Channel Bathymetry

Channel morphology was measured with a Lowrance integrated Global Positioning System/depth sounder at both the Kalskag Bar spawning area and Birch Tree Crossing. Depth/location data were collected at 30 to 60 cm intervals by 1) continuously recording bathymetric data while sediment samples were being collected and 2) through transects run in a zig-zag pattern in an upstream and downstream direction within the study areas. Data files obtained from the Lowrance unit were transformed to GIS data files.

At the time of presumed smelt spawning, sometime after midnight on May 23, the Kuskokwim River discharge was approximately 45,000 cubic feet per second (cfs) as measured at the U.S. Geological Survey Kuskokwim Crooked Creek gage (Station Number 15304000). During the subsequent 5 days, the stage decreased by 1.07 ft to 37,500 cfs. To correct for this decrease in water surface elevation, the measured depths were adjusted to the 45,000 cfs level based on the Crooked Creek gage readings. After applying the correction, depth contours, in 2 ft intervals, were digitized to reveal the channel morphology.

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3. RESULTS

3.1. Smelt Upstream Migration

The 2014 upstream migration was first reported while smelt were passing Bethel on the evening of May 18 (D. Cannon, pers. comm. 2014). The migration was tracked from village-to-village, with an average upstream movement rate of approximately 46 km (30 miles) per day (Table 1). The migration rate appeared to slow as fish arrived in the Kalskag region.

Evidence that the smelt were in the Kalskag region was obtained through observation of gull concentrations and people fishing from boats during an aerial survey by helicopter on May 21. High concentrations of both gulls and fishers were recorded approximately 20 km (12 miles) downstream from Upper Kalskag between 17:45 and 18:40 that evening (Table 2). By 11:00 on May 22, fish were being caught by dip netters fishing from the beach at both Lower and Upper Kalskag. Fishers in boats were targeting the highest concentrations of smelt. The peak of the run was reported to have passed Kalskag around 08:00 on May 22 (M. Stanmayer, pers. comm. to D. Cannon); however, smelt were reported to still be jumping at Kalskag at 22:00 on that day (D. Hoffman, pers. comm. to D. Cannon).

By 10:00 on May 23, smelt were no longer found in the Kalskag region. Concentrations of gulls were no longer found during a helicopter survey of the area, fishers were not active, and no smelt were caught during dip net sampling. D. Hoffman reported that gulls were seen leaving the area in a downstream direction early in the morning of May 23.

3.2. Size and Maturity of Adult Smelt

A sample of 136 rainbow smelt collected by dip net was composed of 27% females (37 fish) and 73% males (99 fish). All females were in spawning condition, with GSI averaging 0.260 (range: 0.088 to 0.393, Table 3). Eggs were loose within the abdominal cavity and the ovaries had lost definition, indicating that spawning was imminent, so it is possible that some of the lower GSI values resulted from premature egg loss from some of the females during sampling.

Lengths of males and females were similar (Figure 2). Males averaged 229.9 mm fork length (range: 200-284 mm) while females averaged 229.2 mm (range: 200-258 mm). Comparison of the two means by t-test indicated no significant difference between male and female length ($p=0.40$, 59 df).

The relationship between fork length and total length was evaluated because studies throughout the state have variously used the two measurements. Analysis of covariance demonstrated there was a significant difference between the fork length/total length relationship for males and females ($p=0.028$), so a relationship was developed for each sex. Lengths can be converted between the two types of measurements with the following conversion equations:

Males: total length = $1.029 \text{ fork length} + 10.400$ ($r^2 = 0.965$)

Females: total length = $1.108 \text{ fork length} - 7.782$ ($r^2 = 0.973$)

If sex of collected fish was not determined, the following equation can be used:

Males+Females: total length = $1.054 \text{ fork length} + 4.602$ ($r^2 = 0.966$)

3.3. Spawn Deposition Survey

The spawn deposition survey initially focused on the area in the vicinity of the greatest densities and last observations of adult smelt, approximately 5 km (3 miles) upstream of Kalskag. A total of 54 sediment samples were obtained to examine for smelt eggs. Deposited smelt eggs were soon observed in the samples that were being condensed for later laboratory examination. Thirty of the 54 samples, or 56%, were confirmed to contain smelt eggs. The identified spawning area covered 6.7 linear km (4.0 miles) of river just upstream from Upper Kalskag, and was centered along a series of gravel bars (Figure 3).

Smelt eggs were found along both sides of the river channel at depths ranging from 1.5 to 4.2 m (5.0 to 13.8 ft). Twenty (67%) of the samples containing eggs were between 1.8 and 2.7 m (6 and 9 ft) deep (Figure 4, Table 4). Current velocities at sites containing eggs averaged 1.1 m/sec (3.7 ft/sec), ranging from 0.6 to 1.1 m/sec (2.0 to 6.2 ft/sec) (Figure 5, Table 4). A t-test of mean values revealed that mean water depths were shallower ($p=0.04$) and mean velocities were lower ($p=0.0002$) at sites that did not contain eggs. Smelt eggs were found in 12 of the 13 samples containing the sediment classes cobble/gravel or gravel/cobble (Table 5). In contrast, only 56% of the 25 samples in which sand was the dominant component contained eggs.

Water temperature during the study period (May 21 to 28) averaged 11.7°C (range: 10.2 to 12.4 °C), with a gradual increase in the mean daily temperature from 11.0 °C on May 21 to 12.0 °C by May 28 (Figure 6). Specific conductance during sediment sampling averaged 206.0 microSiemens/cm (range: 200.6 – 210.9 microSiemens/cm). Because of the narrow range in water temperature and specific conductance, further analyses were not performed with these variables

3.4. Birch Tree Crossing Bathymetry

Bathymetric surveys at Birch Tree Crossing revealed substantial shallows and bars; the main river channel through this reach was relatively narrow (Figure 7).

4. DISCUSSION

4.1. Evaluation of Survey Methods

Some of the survey methods used in this study have not been described elsewhere for studies on rainbow smelt, thus evaluation of their suitability is warranted. The combination of on-site observations of local fishers and aerial survey to identify the upstream movement of smelt proved effective in following the migration and eventually pin-pointing the spawning area. The strategy was successful because of the connections with local fishers established by Dave Cannon, Environmental Director, Native Village of Napaimute. He was able to identify the day in which the smelt would arrive in the Kalskag study area, at which time the aerial survey was successful in identifying the approach to the spawning area and disappearance of the smelt following spawning. Visual confirmation of smelt presence was likely assisted by lower turbidity in 2014 because of unusually low river flow, however, the activity of both local fishers and predatory birds gave ample evidence of smelt presence (Photo Set 1).

The methods used to map spawn deposition borrowed heavily from methods developed to map surf smelt spawn on beach habitat within Puget Sound, Washington (Moulton and Pentilla 2000). The challenge was to obtain sediment samples that might contain deposited eggs. Three types of sediment samplers were tested – an Eckman dredge, a Petite Ponar dredge and a pipe dredge; however, only the pipe dredge was able to successfully sample sediments present in the Kalskag study region. The pipe dredge was dragged downstream while the boat drifted with the current. A sample distance of 60 m (200 ft) was needed in sites dominated by cobble substrate, while a 30-m drift (100 ft) was adequate in areas dominated by gravel or gravel/cobble. At sites with sand, such as along much of the thalweg, the pipe dredge filled within the first 3 m (10 ft). Once the sediment sample was obtained, eggs were readily detecting using the winnowing methods developed for Puget Sound beach sampling.

4.2. Rainbow Smelt Upstream Migration

In 2014, rainbow smelt moved rapidly upstream in the mainstem Kuskokwim River, arriving in Bethel on May 18 and arriving at Kalskag, or 184 river km (114 river miles), 4 days later. This rapid movement caused the migrating adult smelt to be available for harvest for only a short period of time, with each village having a day or two for harvesting before the migration passed upstream. The pattern of fishing indicated that the smelt moved upstream as a single school rather than multiple waves, because once the first wave passed, all fishing ceased. This pattern was reflected in the observations at Kalskag, where gulls accompanied the migrating fish upstream, but left the area immediately after the main group of fish had apparently spawned. Similarly, smelt were sampled easily by dip net from May 21 through May 22, then abruptly ceased to be caught. Local fishers reported that rainbow smelt typically follow the banks of the river during the upstream migration, then immediately return downstream in mid-channel following spawning; observations made during 2014 were consistent with these patterns.

This pattern of a rushed upstream migration covering more than 310 km (193 miles) from the river mouth, or approximately 185 river km (115 miles) upstream from Bethel, followed by an abrupt return downstream was quite different from rainbow smelt spawning runs described elsewhere. In the Togiak River, approximately 160 km south of the Kuskokwim River mouth, a study of spawning rainbow smelt

was confined to the lower 5 km of the river (Dion and Bromaghin 2008). Similarly, Moulton *et al.* (2011) documented a rainbow smelt spawning area in the lower Chipp River approximately 16 km from the river mouth. Studies on the East Coast of the United States typically describe rainbow smelt spawning as distributed within the first suitable riffles upstream from tidal influence (Chase 2006). While the studies of the East Coast describe a rapid return to the nearby marine water following spawning, the Togiak study describes a prolonged spawning period, with peak spawning covering two weeks and ripe or spent smelt being present for up to a month. Tidal influence in the Kuskokwim River extends to Tuluksak at River Kilometer 218 and the smelt continued upstream more than 90 additional km.

Along the east coast of North America, the rainbow smelt spawning run is thought to be keyed by increasing water temperatures following ice-out, with peak spawning reported to be at temperatures between 6 and 9 degrees Celsius (°C) (Belyanina 1969). Spawning smelt are reported to avoid temperatures in excess of 12°C. The date of initial movement into the Kuskokwim River during 2014 is not known because the first reports of the spawning run were at Bethel on May 18, already 125 km upriver from the mouth. Break up at Bethel was on May 5, so it is likely that the spawning run commenced shortly after this date. By the time the smelt migration reached Upper Kalskag, water temperatures were near the upper end of described spawning temperatures (11-12°C).

4.3. Rainbow Smelt Spawning Area in 2014

The egg deposition survey identified a rainbow smelt spawning area covering approximately 6.7 km (4 miles) of river channel just upstream from Upper Kalskag. The smelt spawned in relatively deep water, primarily 1.5 to 3.0 m deep, with some as deep as 4.2 m. Egg deposition was greatest on the sides of the channel rather than on shallow bars and riffles or in the thalweg, which tended to be sand. Spawning in deep water afforded protection from both avian predators and the risk of eggs desiccating if flow decreased during the 2 to 3 week incubation, which would extend into mid-June. Spawning smelt also selected areas of high flow, with water velocities 0.75 to 1.25 m/sec (2.5 to 4.1 ft/sec), which assured a constant flow of well-oxygenated water. The spawning substrates consisted of well-armored cobble/gravel to mixed sand/gravel/cobble, which tend to be stable under most flow regimes except for extreme high flow events. Eggs were not found as frequently in sites that were predominately sand or sand/gravel.

4.4. Stability of Rainbow Smelt Spawning Areas in the Kuskokwim

One of the questions raised in regard to this study was how much variability is there likely to be in the timing and location of rainbow smelt spawning in the Kuskokwim River. One of the main answers from interviews with local resources users regarding spawning location was that spawning usually occurs either upstream or downstream of Kalskag. One person with a cabin upstream from Birch Tree Crossing was interviewed on May 23 and gave his opinion that smelt usually go about 3 to 4 miles above Kalskag, then turn back, the precise location where spawning had occurred just hours earlier. Another user said they sometimes approach the Birch Tree Crossing area. Dave Cannon, Native Village of Napaimute, has spoken with people who say they have dipped smelt near Aniak. As indicated in Figure 1, smelt harvest has been reported as far upstream as Chuathbaluk (Shelden *et al.* 2014).

Much of the speculation relative to where smelt spawning might occur in 2014 arose because of an unusual pattern to the breakup flows. The river flow steadily decreased through May rather than showing

a peak in flow normally seen following breakup (Figure 8). By mid- to late May, flow was the lowest seen during May for at least the last 6 years. There was some thought that lower flow during May could mean the smelt would ascend higher in the river than under a higher flow.

It was evident from working on the river, conducting depth transects and sampling sediment that the physical characteristics of spawning habitat observed in 2014 are in abundant supply in this portion of the river. The substrate composition, depths, velocities and channel structure selected during 2014 were commonly available, so the exact spawning location may show considerable annual variation.

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TABLES

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Table 1: Upstream movement of rainbow smelt in the Kuskokwim River as reported by village observers, 2014.

Date	Observation	River	River	Approx.	Approx.
		Miles	Kilometers	Miles per day	KM per day
5/18/2014	Smelt have been passing Bethel all evening	78	125	0	0
5/19/2014	Smelt reported in Akiak this morning	118	190	40	65
	Smelt reported at Tuluksak by evening	136	218	36	56
5/20/2014	Fish caught near Bogus Creek, about 10 miles upstream of Tulusak	146	235	28	45 (relative to Akiak)
5/21/2014	Smelt found about 12 miles downstream from Lower Kalskag	180	289	34	54
5/22/2014	Smelt passed Lower and Upper Kalskag all day	192	309	12	20
5/23/2014	Smelt no longer in the Kalskag study area				
Average Movement Rate:				30	48

Source: D. Cannon, Environmental Director, Native Village of Napaimute, 2014

Table 2: Aerial observations during helicopter survey for rainbow smelt activity near Kalskag, 2014.

Station	Latitude (NAD83)	Longitude (NAD83)	Date	Time	Observation	
					Type	Comment
B001	61.41445	-160.53591	21-May-14	17:42	Gull	a few gulls
B001	61.41445	-160.53591	21-May-14	17:42	Fishing	3 boats dipping
B002	61.41405	-160.55294	21-May-14	17:44	Gull	~15 gulls
B003	61.42583	-160.57258	21-May-14	17:47	Gull	~6 boats
B003	61.42583	-160.57258	21-May-14	17:47	Fishing	lots of gulls
B004	61.43946	-160.51594	21-May-14	18:02	Gull	~20 gulls
B005	61.39493	-160.59770	21-May-14	18:06	Gull	~65 gulls
B006	61.30461	-160.62668	21-May-14	18:09	Gull	~30 gulls
B007	61.28416	-160.75973	21-May-14	18:15	Gull	~15 gulls
B011	61.41563	-160.59006	21-May-14	18:32	Gull	~100 gulls, photo
B011	61.41563	-160.59006	21-May-14	18:32	Fishing	3 boats on cut bank side
B012	61.41634	-160.53383	21-May-14	18:37	Fishing	7 boats fishing
B013	61.41622	-160.53235	21-May-14	18:39	Fishing	7 boats fishing
B016	61.53021	-160.33644	22-May-14	11:20	Gull	~15 gulls
B017	61.51079	-160.36280	22-May-14	11:22	Fishing	8 people, 3-4 nets, Lower Kalskag
B018	61.50461	-160.37126	22-May-14	11:23	Smelt	school of smelt along bank
B019	61.48892	-160.37734	22-May-14	11:25	Gull	~20 gulls
B020	61.47722	-160.38922	22-May-14	11:26	Smelt	flashing fish
B021	61.47394	-160.40502	22-May-14	11:27	Gull	~30 gulls
B022	61.44573	-160.49518	22-May-14	11:30	Gull	~75 gulls, sitting, photos
B023	61.39240	-160.59154	22-May-14	11:37	Gull	~50 gulls sitting
B024	61.48778	-160.37899	22-May-14	11:54	Gull	~60 gulls
B025	61.53194	-160.29849	22-May-14	12:34	Gull	~25 gulls
B025	61.53194	-160.29849	22-May-14	12:34	Smelt	jumping fish
B026	61.50500	-160.24800	22-May-14	12:40	Fishing	dipnetter in boat
B027	61.53630	-160.30960	22-May-14	12:49	Smelt	jumping fish
B028	61.53071	-160.27693	22-May-14	14:04	Smelt	long band of smelt, photos
B029	61.53334	-160.26114	22-May-14	14:09	Smelt	long band of smelt, photos
B030	61.53449	-160.25691	22-May-14	14:09	Smelt	long band of smelt, photos
B031	61.53101	-160.27418	22-May-14	17:49	Smelt	jumper near shore
B032	61.53142	-160.27070	22-May-14	17:50	Smelt	jumper near shore
B033	61.53281	-160.26410	22-May-14	17:51	Smelt	jumper near shore
B034	61.53770	-160.24704	22-May-14	17:52	Smelt	jumper near shore
B035	61.53235	-160.22456	22-May-14	17:57	Gull	~16 gulls
B036	61.53341	-160.24480	22-May-14	17:58	Gull	~30 gulls
B037	61.53718	-160.24996	22-May-14	18:05	Smelt	jumper near shore
B038	61.53762	-160.23246	22-May-14	18:06	Smelt	jumper near shore
B040	61.54824	-160.12341	23-May-14	9:32	Gull	3 gulls

Table 3: Gonadosomatic indices (GSI) for female rainbow smelt caught by dip net near Kalskag, 2014.

Fork Length (mm)	Total Weight (gm)	Gonad Weight (GM)	GSI	
198	64.1	13.8	0.274	
200	56.9	8.1	0.166	
200	62.2	13.3	0.272	
203	58.9	6.2	0.118	
204	58.4	5.1	0.096	
205	61.5	6.4	0.116	
210	85.1	24	0.393	
212	85.4	19.2	0.290	
216	78.9	15.1	0.237	
218	103.4	22.2	0.273	
218	92.1	21.4	0.303	
219	91.8	21.9	0.313	
220	86.7	18	0.262	
220	87.9	19.7	0.289	
220	93.9	21.3	0.293	
221	96.2	23.1	0.316	
222	102.8	19.9	0.240	
222	78.2	15.4	0.245	
227	94.3	7.6	0.088	
228	80.7	8.3	0.115	
228	113.7	26.5	0.304	
228	96.4	22.6	0.306	
229	99.3	19.9	0.251	
230	113.1	26.4	0.304	
232	115.5	25.6	0.285	
233	90.1	17.6	0.243	
234	96.9	15.9	0.196	
238	114.5	29.5	0.347	
239	125.1	26.5	0.269	
240	124.3	32	0.347	
243	107.4	16.7	0.184	
243	116.6	26.2	0.290	
244	127.9	30.6	0.314	
250	125.9	35.1	0.387	
252	147.2	32.3	0.281	
253	134.2	31.7	0.309	
255	173.7	41	0.309	

Summary:	GSI
Mean	0.260
Standard Deviation	0.077
Minimum	0.088
Maximum	0.393
Sample Size	37

Table 4: Comparison of water depth and velocity at sites where eggs were detected to those where eggs were not detected.

Depth						
Category	Units	Mean Depth	Standard Deviation	Minimum Depth	Maximum Depth	Sample Size
Eggs Present	meters	2.59	0.81	1.52	4.22	30
	feet	8.5	2.7	5.0	13.8	30
None Found	meters	2.09	1.21	0.71	4.53	24
	feet	6.9	4.0	2.3	14.9	24

Water Velocity						
Category	Units	Mean Velocity	Standard Deviation	Minimum Velocity	Maximum Velocity	Sample Size
Eggs Present	m/sec	1.12	0.29	0.62	1.88	30
	ft/sec	3.7	1.0	2.0	6.2	30.0
None Found	m/sec	0.77	0.38	0.27	1.50	24
	ft/sec	2.5	1.2	0.9	4.9	24.0

Table 5: Sediment types associated with the presence of rainbow smelt eggs.

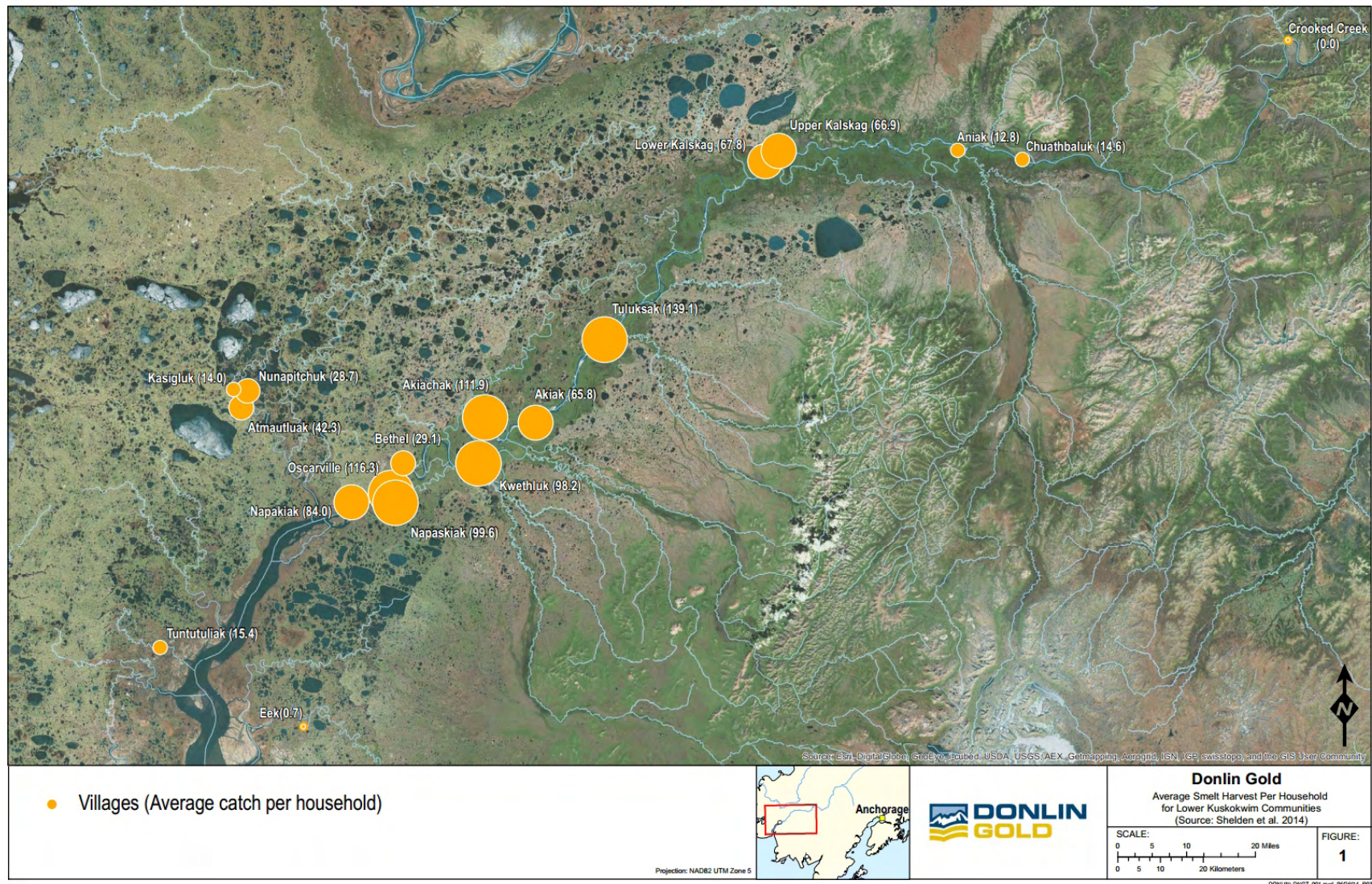
Sediment Category	Eggs Present	Total Samples	% Containing Eggs
cobble/gravel and gravel/cobble	12	13	92.3
gravel/sand	3	4	75.0
sand/gravel/cobble	5	7	71.4
sand/gravel	6	12	50.0
sand	3	6	50.0
Total	29	42	69.0

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FIGURES

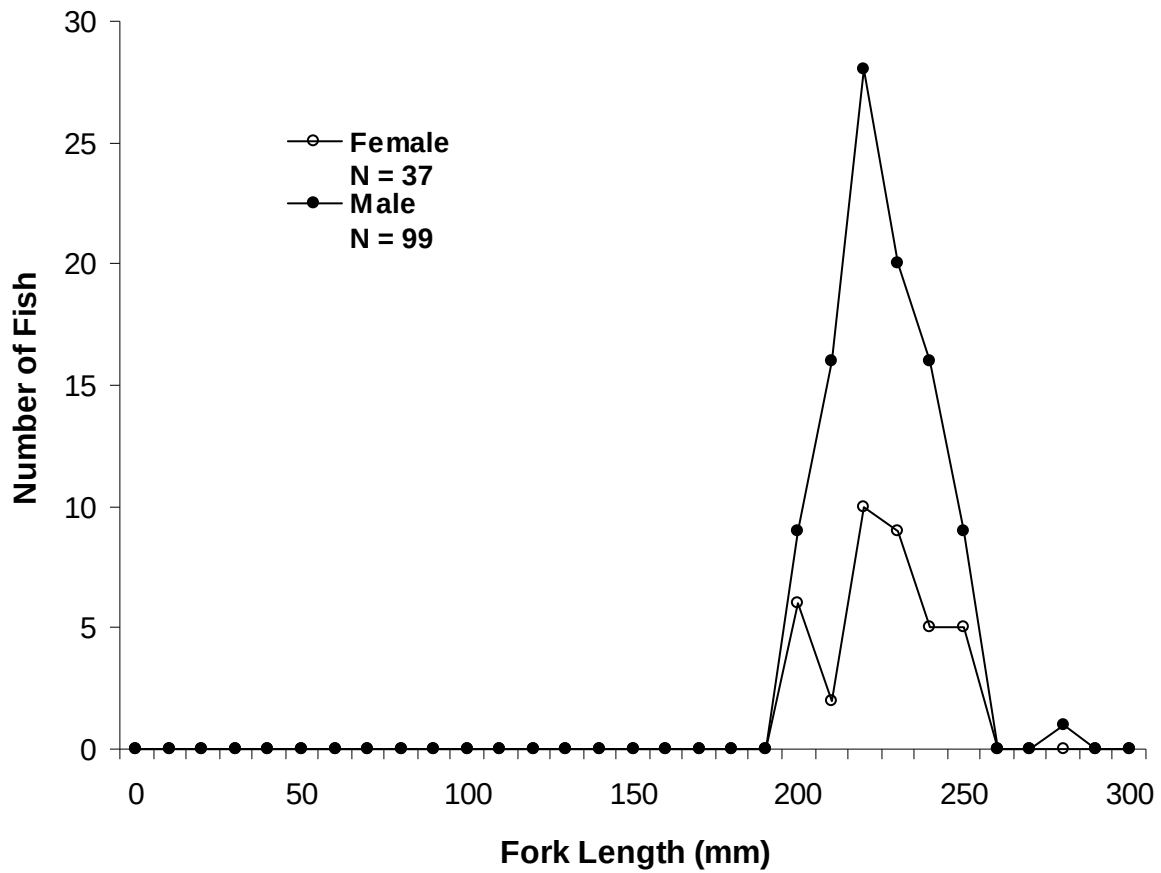
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Figure 1: Average smelt harvest per household for lower Kuskokwim communities.
(Source: Sheldon et al. 2014).



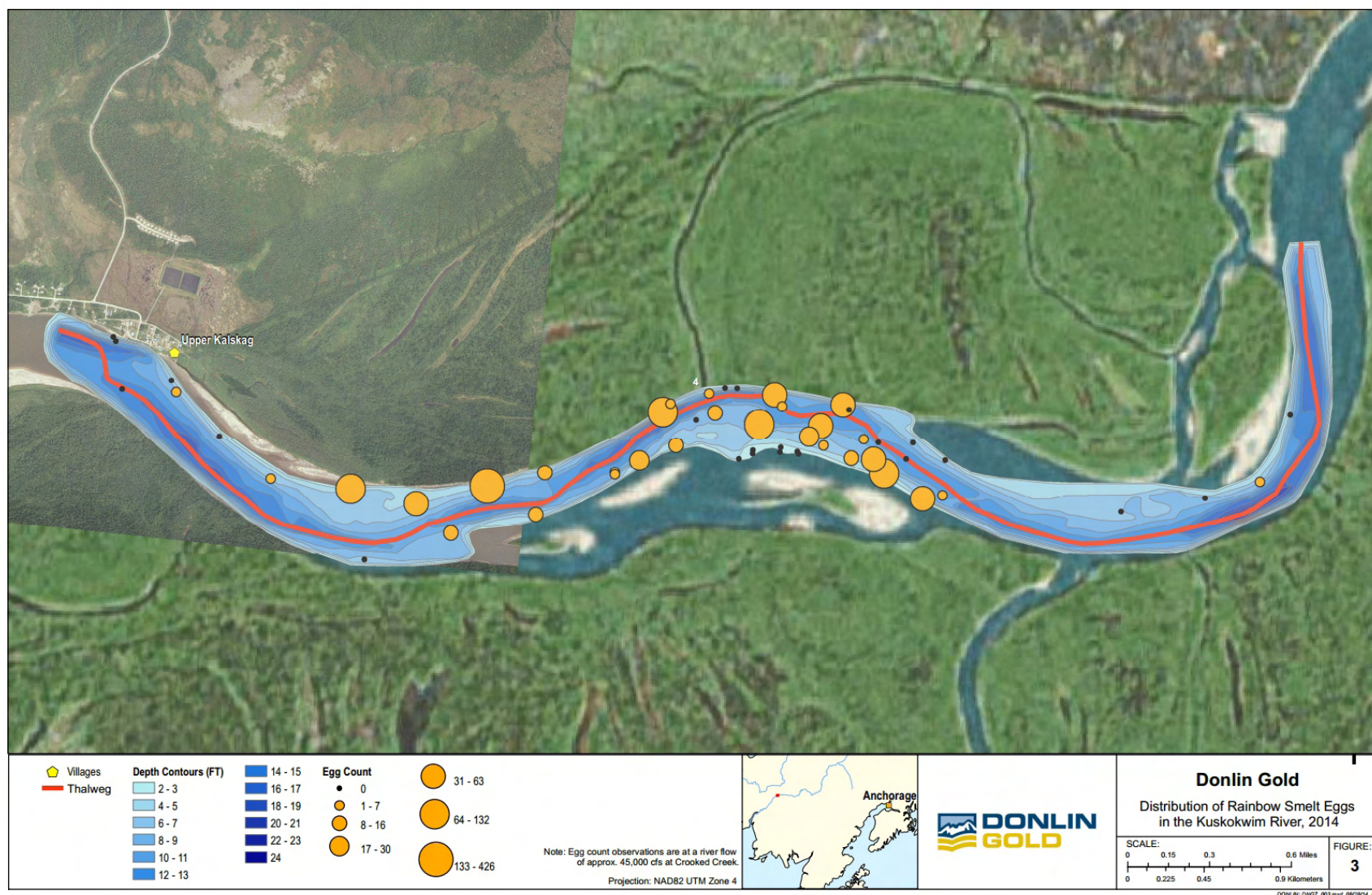
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Figure 2: Length frequencies of male and female rainbow smelt from the Kuskokwim River showed a similar distribution in 2014.



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Figure 3: Distribution of rainbow smelt eggs in the Kuskokwim River, 2014.



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Figure 4: Samples containing eggs were concentrated at depths between 1.5 and 3.0 m, but ranged to 4.5 m.

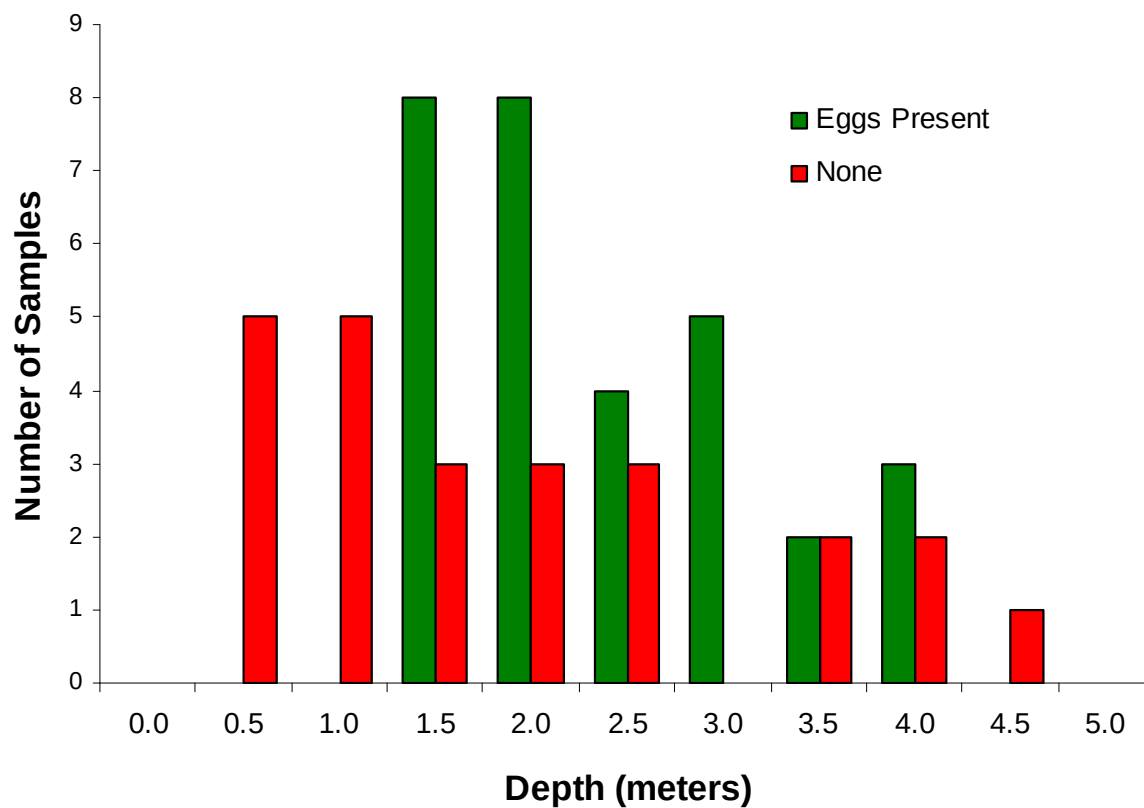


Figure 5: Samples containing rainbow smelt eggs tended to be in higher water velocities than samples without eggs.

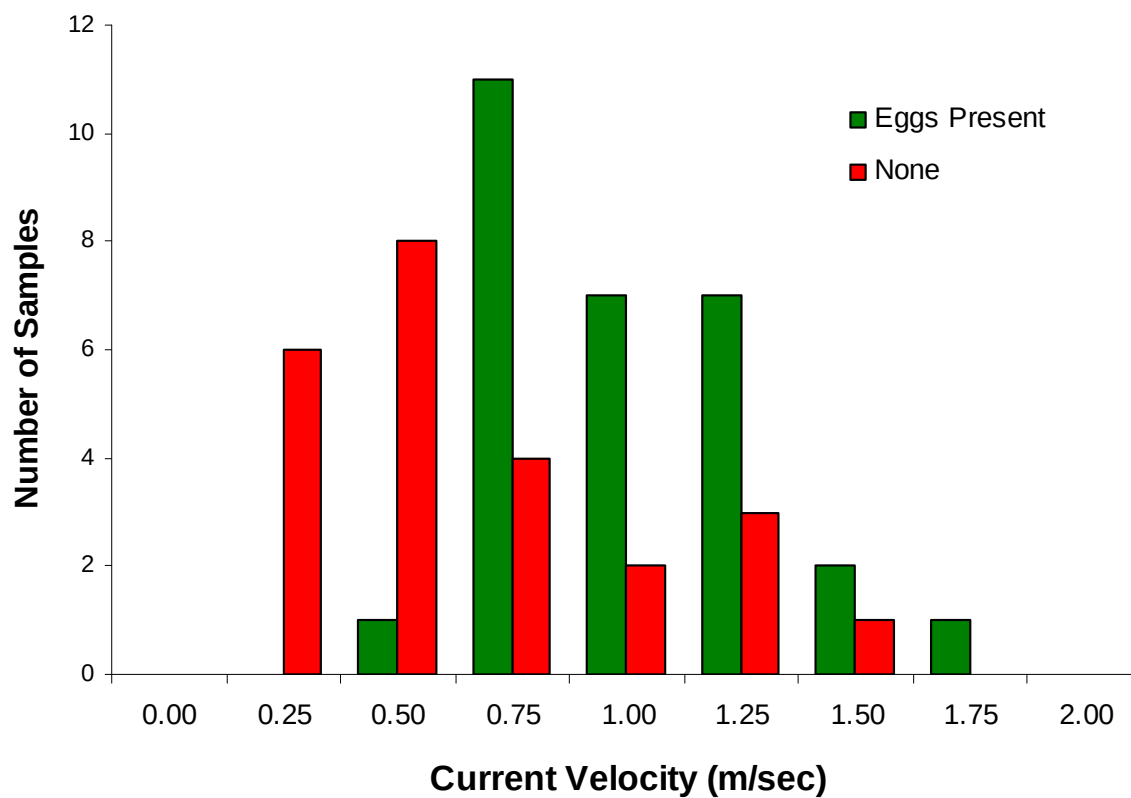
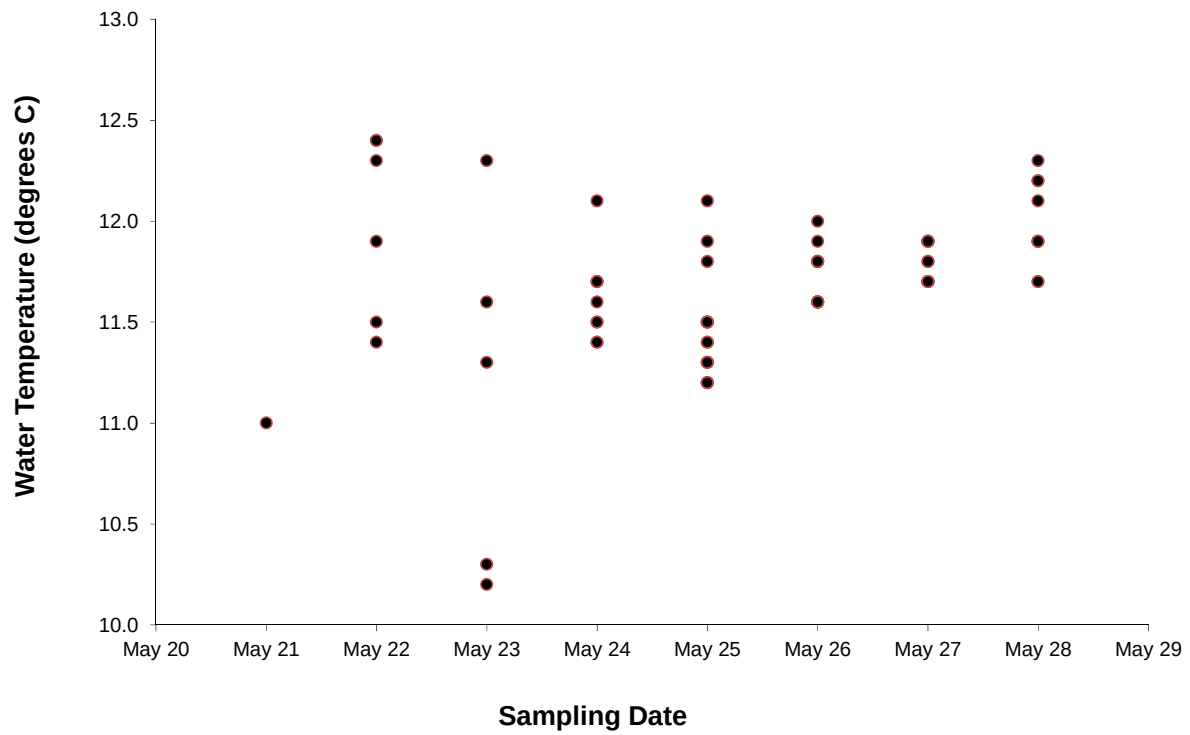
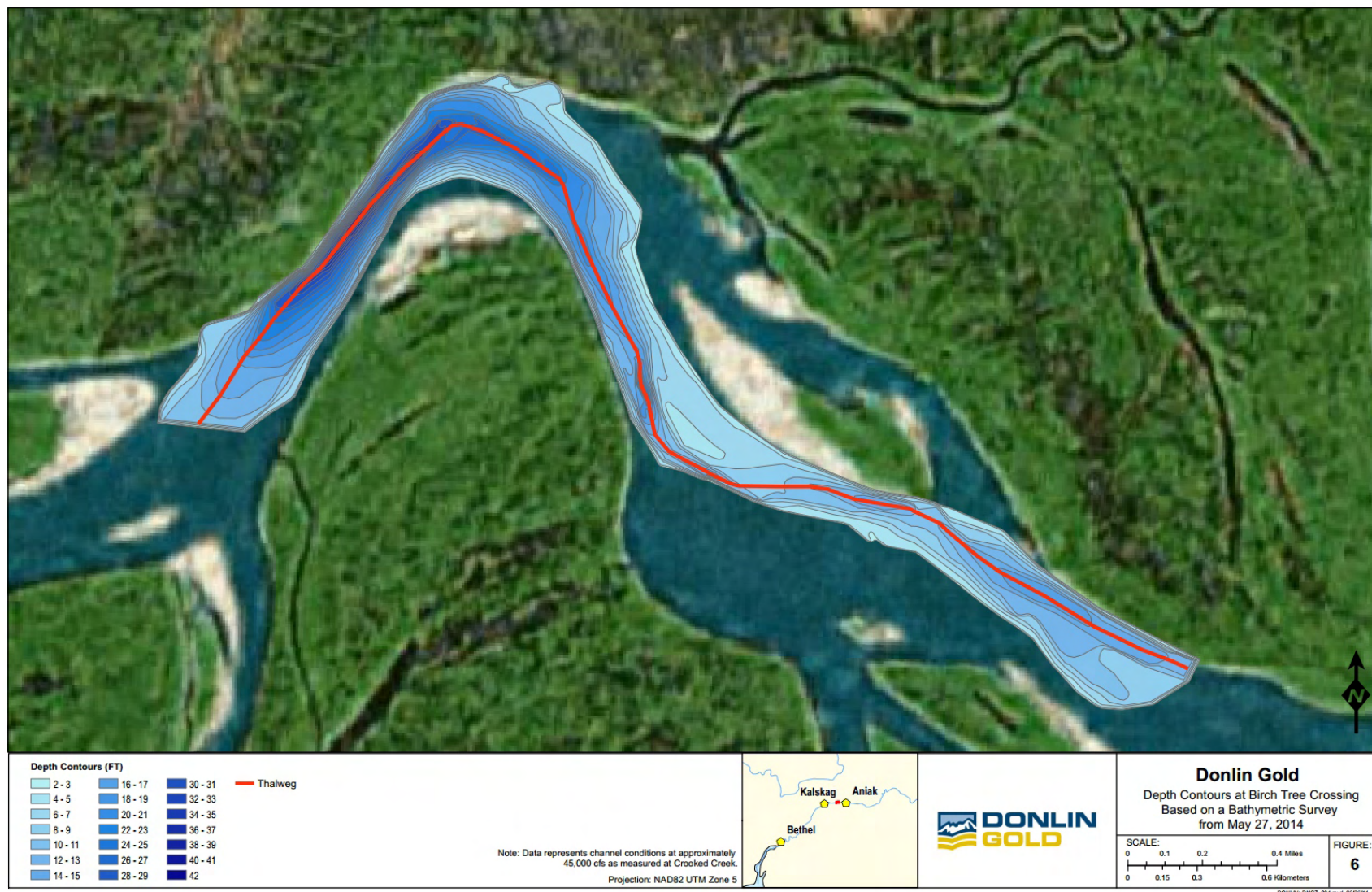


Figure 6: Water temperature in the Kalskag region during the 2014 rainbow smelt spawning survey.



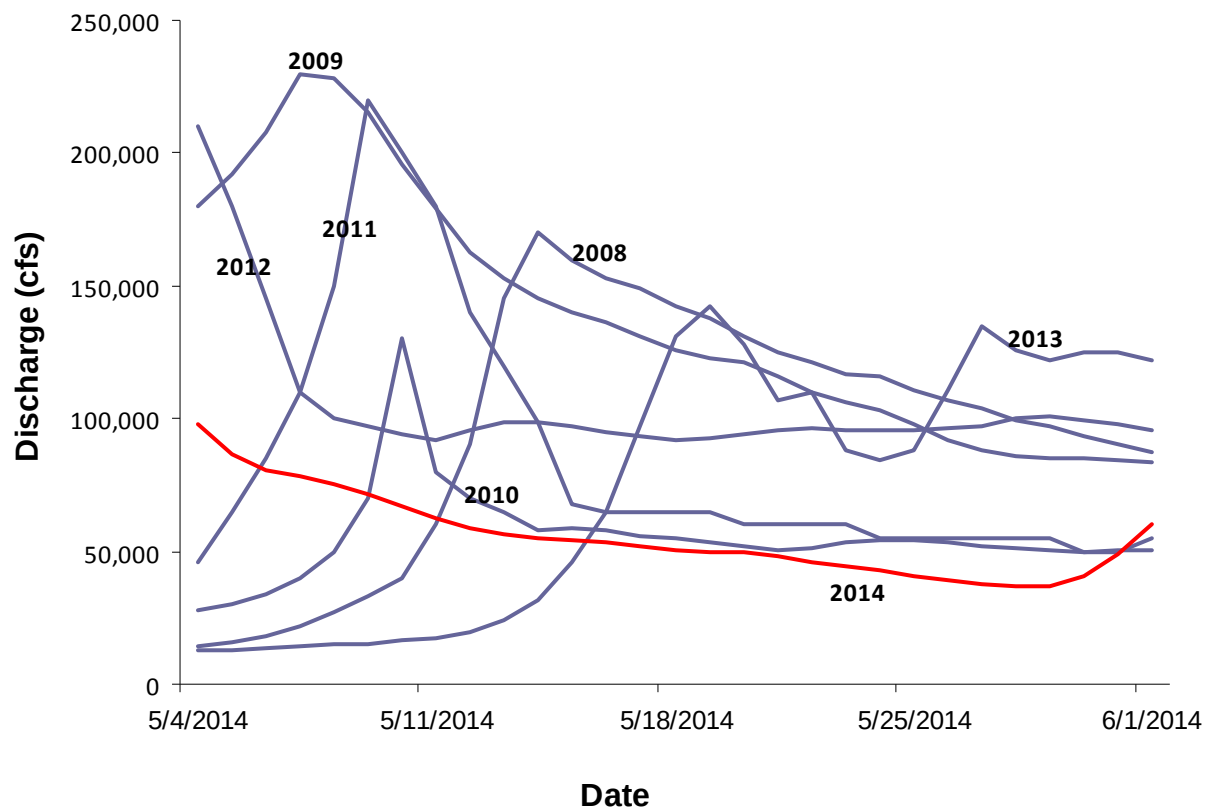
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Figure 7: Depth contours at Birch Tree Crossing based on a bathymetric survey from May 27, 2014.



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Figure 8: Kuskokwim River discharge during May, 2008 to 2014, showing the unusual post-breakup flow pattern in 2014 (flows in 2014 shown in red)



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PHOTOGRAPHS

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PHOTO SET 1: EVIDENCE OF SMELT PRESENCE PRIOR TO SPAWNING NEAR KALSKAG, MAY 22, 2014



Photograph 1a: Gull Concentration at Gravel Bar Upstream from Kalskag, May 22, 2014



Photograph 2b: Smelt Fishers Downstream From Lower Kalskag, May 22, 2014

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PHOTO SET 2: PIPE DREDGE USED TO SAMPLE SMELT SPAWNING SUBSTRATE NEAR KALSKAG, 2014



Photograph 3a: Pipe dredge used to sample smelt eggs, May 2014.



Photograph 4b: Emptying sediment sample from pipe dredge prior to processing.

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PHOTO SET 3: PROCESSING SMELT SPAWNING SUBSTRATE NEAR KALSKAG, 2014



Photograph 5a: Processing sediment samples, May 2014.



Photograph 6b: Rainbow smelt eggs on a 0.5 mm screen.

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DATA APPENDIX

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Appendix A

Results of Dip Net Sampling

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Appendix A. Results of dip net sampling for adult rainbow smelt in the Kalskag region of the Kuskokwim River, 2014, with length, sex and physical data for all captured smelt.

Station	Latitude (NAD83)	Longitude (NAD83)	Date	Start Time	End Time	No. of Dips	Fork Length (mm)	Total Length (mm)	Sex	Water Depth (ft)	Water Velocity (ft/sec)	Water Temp (°C)	Specific Conductance (microS/cm)
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	230	250	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	203	211	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	231	245	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	220	235	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	219	236	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	244	262	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	214	229	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	226	233	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	250	269	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	242	261	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	225	233	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	234	251	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	219	229	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	207	224	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	242	260	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	216	234	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	220	236	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	237	255	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	245	254	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	219	230	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	203	219	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	200	214	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	205	222	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	220	236	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	240	256	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	235	254	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	206	222	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	205	221	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	200	214	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	250	269	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	232	251	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	240	256	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	223	241	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	245	263	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	202	217	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	230	258	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	224	240	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	255	271	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	229	246	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	212	228	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	220	238	F	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	212	227	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	225	242	M	6.0		11.0	178.1
A003	61.41657	160.59659	5/21/2014	18:46	18:57	20	239	256	F	6.0		11.0	178.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	239	254	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	226	245	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	284	300	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	243	265	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	211	230	M	1.4	0.9	11.5	185.1

Appendix A. Results of dip net sampling for adult rainbow smelt in the Kalskag region of the Kuskokwim River, 2014, with length, sex and physical data for all captured smelt.

Station	Latitude	Longitude	Date	Start	End	No. of Sweeps	Fork Length	Total Length	Sex	Depth	Velocity	Temp	Specific
	(NAD83)	(NAD83)		Time	Time		(mm)	(mm)					Conductance
										(ft)	(ft/sec)	(°C)	(microS/cm)
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	224	245	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	203	220	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	225	243	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	236	256	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	216	234	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	258	280	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	245	266	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	238	258	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	241	259	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	236	255	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	236	248	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	216	230	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	223	240	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	230	248	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	225	247	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	258	279	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	208	227	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	257	276	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	238	256	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	231	249	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	244	265	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	246	265	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	222	239	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	204	224	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	209	227	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	223	244	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	235	257	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	225	244	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	210	233	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	218	237	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	220	238	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	249	267	F	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	233	252	M	1.4	0.9	11.5	185.1
A005	61.53690	160.31410	5/22/2014	12:35	12:45	10	223	238	M	1.4	0.9	11.5	185.1
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	227	239	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	247	262	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	214	229	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	225	236	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	224	238	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	222	237	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	228	244	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	217	230	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	218	236	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	233	250	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	231	248	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	240	256	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	259	278	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	233	249	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	231	244	F	2.1	0.9	11.4	182.2

Appendix A. Results of dip net sampling for adult rainbow smelt in the Kalskag region of the Kuskokwim River, 2014, with length, sex and physical data for all captured smelt.

Station	Latitude (NAD83)	Longitude (NAD83)	Date	Start Time	End Time	No. of Sweeps	Fork Length (mm)	Total Length (mm)	Sex	Depth (ft)	Velocity (ft/sec)	Temp (°C)	Specific Conductance (microS/cm)
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	243	261	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	237	255	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	223	239	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	222	238	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	230	248	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	226	242	F	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	234	252	F	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	224	240	F	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	235	250	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	230	246	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	207	224	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	214	229	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	238	255	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	229	245	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	247	265	M	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	244	261	F	2.1	0.9	11.4	182.2
A006	61.53543	160.25534	5/22/2014	14:17	14:34	5	225	240	F	2.1	0.9	11.4	182.2
A007	61.59203	160.20146	5/22/2014	15:15	15:35	25	no catch			1.8	1.1	11.9	184.2
A008	61.63852	160.17935	5/22/2014	15:48	16:03	19	no catch			2.7	0.6	12.4	176.9
A009	61.53777	160.22908	5/22/2014	16:33	16:41	25	no catch			1.5	1.2	12.4	185.8
A010	61.53755	160.24973	5/22/2014	16:54	17:22		204	220	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		235	249	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		225	241	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		235	253	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		226	244	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		216	233	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		225	241	F	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		251	271	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		226	240	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		250	269	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		239	252	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		223	239	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		252	270	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		244	264	F	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		250	272	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		254	275	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		220	243	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		243	263	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		242	260	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		221	240	M	2.0	0.9	12.3	180.6
A010	61.53755	160.24973	5/22/2014	16:54	17:22		214	231	M	2.0	0.9	12.3	180.6
A011	61.53540	160.25540	5/23/2014	10:47	10:59	20	no catch			1.7	1.7	10.3	185.6
A012	61.53762	160.24965	5/23/2014	11:30	11:44	20	no catch			1.9	0.9	10.2	184.8
A014	61.45465	160.44800	5/23/2014	13:53	14:05	20	no catch			1.6	0.5	12.3	172.9
A015	61.41846	160.59566	5/23/2014	14:30	14:45	20	no catch					11.6	183.1
C001	61.53478	160.23972	5/23/2014	10:50	11:00	20	no catch					11.3	170.7

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Appendix B

Results of Pipe Dredge Sampling

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Appendix B. Results of sampling rainbow smelt embryos with a pipe dredge in the Kukskokwim River, 2014.

Sample No.	Station	Latitude (NAD83)	Longitude (NAD83)	Date	Time	Eggs	No. Eggs	Depth (ft)	Velocity (ft/sec)	Water Temp (°C)	Specific Conductance (microS/cm)	Comments
ORNRC2014-211	A017	61.53422	160.31284	5/24/2014	13:00	No	0	13.8	4.31	11.5	205.5	PIPE DREDGE - 20FT
ORNRC2014-212	A019	61.53690	160.31444	5/24/2014	13:53	No	0	2.9	1.25	12.1	210.1	PIPE DREDGE - 20FT
ORNRC2014-213	A020	61.53481	160.23766	5/24/2014	16:32	No	0	2.5	1.45	11.7	201.6	PIPE DREDGE - 20FT
ORNRC2014-214	A021	61.53492	160.23782	5/24/2014	17:22	No	0	3.5	1.94	11.7	200.7	PIPE DREDGE - 35FT
ORNRC2014-216	A022	61.53782	160.24655	5/25/2014	12:04	No	0	3.6	1.19	12.1	210.9	PIPE DREDGE - 18FT
ORNRC2014-215	B041	61.53419	160.24417	5/24/2014	18:22	No	0	3.0	0.94	11.7	200.7	PIPE DREDGE - 10FT
ORNRC2014-001	C001	61.53478	160.23972	5/24/2014	16:50	No	0	2.3	0.87	11.4	200.9	SHALLOW
ORNRC2014-002	C002	61.53504	160.23972	5/24/2014	17:20	No	0	3.6	1.74	11.4	200.9	DEEP
ORNRC2014-003	C003	61.53455	160.24274	5/24/2014	18:10	No	0	3.1	1.38	11.6	200.8	SHALLOW
ORNRC2014-004	C004	61.53473	160.24274	5/24/2014	18:35	No	0	3.8	1.76	11.5	200.6	DEEP
ORNRC2014-005	C005	61.53788	160.24524	5/25/2014	10:15	No	0	3.9	2.33	11.9	210.5	50FT DRAG
ORNRC2014-056	C001A	61.53040	160.29538	5/28/2014	12:37	Yes	5	6.9	2.53	12.2	207.3	
ORNRC2014-057	C002A	61.53232	160.30156	5/28/2014	12:49	No	0	5.5	1.80	12.3	207.3	
ORNRC2014-058	C003A	61.53496	160.30750	5/28/2014	12:50	No	0	6.1	2.22	11.9		
ORNRC2014-059	C004A	61.53438	160.30684	5/28/2014	12:57	Yes	4	8.2	2.03	12.1	207.8	
ORNRC2014-060	C005A	61.53670	160.31411	5/28/2014	13:06	No	0	7.5	2.16	12.2	207.8	
ORNRC2014-217	C007	61.53646	160.24734	5/25/2014	13:04	Yes	16	8.9	4.73	11.5	206.4	EST. 200FT
ORNRC2014-218	C008	61.53743	160.24823	5/25/2014	13:22	Yes	2	8.3	2.92	11.8	210.1	EST. 100FT
ORNRC2014-219	C009	61.53611	160.22360	5/25/2014	14:15	Yes	45	9.9	4.38	11.4	204.9	EST. 100FT JAR 1 OF 2
ORNRC2014-225	C009	61.53611	160.22360	5/25/2014	14:15	Yes	77	9.9	4.38	11.4	204.9	EST. 100FT JAR 2 OF 2
ORNRC2014-220	C010	61.53453	160.25125	5/25/2014	14:33	Yes	10	5.0	4.32	11.5	204.4	EST. 100FT
ORNRC2014-006	C011	61.53428	160.22803	5/25/2014	15:22	Yes	3	5.6	3.28	11.2	202.1	JAR 1 OF 2
ORNRC2014-221	C011	61.53428	160.22803	5/25/2014	15:22	Yes	118	5.6	3.28	11.2	202.1	JAR 2 OF 2
ORNRC2014-007	C012	61.53596	160.23070	5/25/2014	15:28	Yes	5	10.7	6.18	11.3	206.0	JAR 1 OF 2
ORNRC2014-222	C012	61.53596	160.23070	5/25/2014	15:28	Yes	1	10.7	6.18	11.3	206.0	JAR 2 OF 2
ORNRC2014-223	C013	61.53266	160.25761	5/25/2014	15:38	Yes	4	7.4				
ORNRC2014-224	C014	61.53317	160.22346	5/25/2014	17:45	Yes	43	5.1	3.53	11.2	203.0	PIPE DREDGE - 200FT
ORNRC2014-226	C015	61.53346	160.22133	5/25/2014	17:56	Yes	5	12.6	5.39	11.2	205.6	PIPE DREDGE - 300FT
ORNRC2014-227	C016	61.53587	160.22905	5/25/2014	18:00	No	0	11.7	4.54	11.3	207.1	PIPE DREDGE - 200FT
ORNRC2014-228	C017	61.53762	160.23338	5/25/2014	18:08	Yes	43	13.8	3.21	11.5	209.7	PIPE DREDGE - 200FT
ORNRC2014-009	D007	61.52496	160.22935	5/26/2014	12:35	Yes	63	8.8	4.48	11.6	205.1	
ORNRC2014-010	D008	61.53640	160.23558	5/26/2014	12:50	Yes	40	10.6	4.21	11.6	205.4	
ORNRC2014-011	D009	61.53577	160.23672	5/26/2014	13:05	Yes	30	7.6	3.24	11.6	203.6	
ORNRC2014-012	D010	61.53490	160.23183	5/26/2014	13:23	Yes	15	6.7	3.69	11.6	202.9	

Appendix B. Results of sampling rainbow smelt embryos with a pipe dredge in the Kukskokwim River, 2014.

Sample No.	Station	Latitude (NAD83)	Longitude (NAD83)	Date	Time	Eggs	No. Eggs	Depth (ft)	Velocity (ft/sec)	Water Temp (°C)	Specific Conductance (microS/cm)	Comments
ORNRC2014-013	D011	61.53740	160.23265	5/26/2014	13:35	No	0	14.1	3.17	11.8	209.9	
ORNRC2014-014	D012	61.53606	160.22522	5/26/2014	13:43	No	0	8.8	2.84	11.8	209.8	
ORNRC2014-015	D013	61.53774	160.24100	5/26/2014	13:58	Yes	41	13.4	4.67	11.8	209.3	
ORNRC2014-016	D015	61.53667	160.25235	5/26/2014	14:12	Yes	1	6.7	2.80	12.0	210.3	
ORNRC2014-017	D016	61.53620	160.25308	5/26/2014	14:18	Yes	119	13.3	5.07	11.9	209.9	
ORNRC2014-018	D017	61.53277	160.25763	5/26/2014	14:24	Yes	7	11.0	3.41	11.6	204.3	
ORNRC2014-019	D018	61.53537	160.23505	5/26/2014	14:35	Yes	6	7.0	3.62	11.6	203.1	
ORNRC2014-020	D019	61.53534	160.22148	5/26/2014	14:44	No	0	6.8	3.10	11.8	210.3	JAR 1 OF 2
ORNRC2014-021	D019	61.53534	160.22148	5/26/2014	14:44	No	0	6.8	3.10	11.8	210.3	JAR 2 OF 2
ORNRC2014-043	D021	61.53578	160.22578	5/27/2014	11:42	No	0	11.9	4.05	11.8	207.9	
ORNRC2014-044	D022	61.53719	160.24004	5/27/2014	11:56	Yes	1	12.4	4.24	11.8	207.4	
ORNRC2014-045	D023	61.53599	160.24935	5/27/2014	12:01	No	0	8.5	4.62	11.7	205.6	
ORNRC2014-046	D024	61.53353	160.25507	5/27/2014	12:06	Yes	26	7.3	2.97	11.7	203.5	
ORNRC2014-047	D025	61.53234	160.26532	5/27/2014	12:11	Yes	15	6.5	3.61	11.9	209.8	
ORNRC2014-048	D026	61.53129	160.27148	5/27/2014	12:24	Yes	426	6.5	2.48	11.9	209.9	
ORNRC2014-049	D027	61.52994	160.27908	5/27/2014	12:37	Yes	45	6.3	3.26	11.9	209.3	
ORNRC2014-050	D028	61.53034	160.28649	5/27/2014	12:43	Yes	132	5.6	3.18	11.9	209.9	
ORNRC2014-051	D029	61.53006	160.26581	5/27/2014	12:54	Yes	12	7.3	2.96	11.7	204.2	
ORNRC2014-052	D030	61.52861	160.27490	5/27/2014	13:03	Yes	15	9.9	3.21	11.7	204.4	
ORNRC2014-055	D031	61.52669	160.28410	5/27/2014	17:21	No	0	8.8	3.67	11.7	203.0	
ORNRC2014-061	D032	61.53603	160.18658	5/28/2014	17:08	Yes	1	5.9	2.58	11.9		
ORNRC2014-062	D033	61.53485	160.19243	5/28/2014	17:15	No	0	6.3	2.58	11.9		
ORNRC2014-063	D034	61.53366	160.20149	5/28/2014	17:21	No	0	7.8	2.17	11.7		
ORNRC2014-064	D035	61.53971	160.18407	5/28/2014	17:36	No	0	14.9	4.92	11.7		

Appendix C

Summary of Data Collected at Each Egg Sampling Station

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Appendix C. Summary of data associated with each station sampled for rainbow smelt eggs near Kalskag, 2014.

Station	Latitude (NAD83)	Longitude (NAD83)	Date	Eggs Present	Number of Eggs	Observed Depth (ft)	Stage Correction (ft)	Corrected Depth (ft)	Water Velocity (ft/sec)	Water Temp (°C)	Specific Conductance (microS/cm)	Substrate Classification	Distance Sampled (ft)
D009	61.53577	160.23672	5/26/2014	Yes	30	6.7	0.88	7.6	3.24	11.6	203.6	cobble	
D010	61.53490	160.23183	5/26/2014	Yes	15	5.7	0.95	6.7	3.69	11.6	202.9	cobble	
D018	61.53537	160.23505	5/26/2014	Yes	6	5.9	1.09	7.0	3.62	11.6	203.1	cobble	
D035	61.53971	160.18407	5/28/2014	No	0	13.7	1.14	14.9	4.92	11.7		cobble	
C014	61.53317	160.22346	5/25/2014	Yes	43	4.5	0.59	5.1	3.53	11.2	203.0	cobble/gravel	200
C015	61.53346	160.22133	5/25/2014	Yes	5	12.0	0.61	12.6	5.39	11.2	205.6	cobble/gravel	300
D007	61.52496	160.22935	5/26/2014	Yes	63	7.7	1.04	8.8	4.48	11.6	205.1	cobble/gravel	
D025	61.53234	160.26532	5/27/2014	Yes	15	5.4	1.07	6.5	3.61	11.9	209.8	cobble/gravel	
D027	61.52994	160.27908	5/27/2014	Yes	45	5.2	1.03	6.3	3.26	11.9	209.3	cobble/gravel	
D032	61.53603	160.18658	5/28/2014	Yes	1	4.8	1.08	5.9	2.58	11.9		cobble/gravel	
D026	61.53129	160.27148	5/27/2014	Yes	426	5.4	1.03	6.5	2.48	11.9	209.9	cobble/gravel/sand	
C008	61.53743	160.24823	5/25/2014	Yes	2	7.7	0.53	8.3	2.92	11.8	210.1	gravel/cobble	100
D016	61.53620	160.25308	5/26/2014	Yes	119	12.4	0.88	13.3	5.07	11.9	209.9	gravel/cobble	
C010	61.53453	160.25125	5/25/2014	Yes	10	4.4	0.56	5.0	4.32	11.5	204.4	gravel/sand	100
C011	61.53428	160.22802	5/25/2014	Yes	121	5.0	0.56	5.6	3.28	11.2	202.1	gravel/sand	
D029	61.53006	160.26581	5/27/2014	Yes	12	6.0	1.28	7.3	2.96	11.7	204.2	gravel/sand	
D031	61.52669	160.28410	5/27/2014	No	0	7.7	1.06	8.8	3.67	11.7	203.0	gravel/sand/cobble	
C009	61.53611	160.22360	5/25/2014	Yes	122	9.3	0.55	9.9	4.38	11.4	204.9	sand	100
C013	61.53266	160.25761	5/25/2014	Yes	4	6.8	0.59	7.4				sand	100
C016	61.53587	160.22905	5/25/2014	No	0	11.1	0.61	11.7	4.54	11.3	207.1	sand	200
D011	61.53740	160.23265	5/26/2014	No	0	13.1	0.98	14.1	3.17	11.8	209.9	sand	
D012	61.53606	160.22522	5/26/2014	No	0	7.8	0.92	8.8	2.84	11.8	209.8	sand	
D017	61.53277	160.25763	5/26/2014	Yes	7	9.9	1.09	11.0	3.41	11.6	204.3	sand	
D022	61.53719	160.24004	5/27/2014	Yes	1	11.3	1.07	12.4	4.24	11.8	207.4	sand/cobble	
C003A	61.53496	160.30750	5/28/2014	No	0	4.9	1.13	6.1	2.22	11.9		sand/gravel	
C004A	61.53438	160.30684	5/28/2014	Yes	4	7.0	1.15	8.2	2.03	12.1	207.8	sand/gravel	
C012	61.53596	160.23069	5/25/2014	Yes	6	10.1	0.59	10.7	6.18	11.3	206.0	sand/gravel	
D013	61.53774	160.24100	5/26/2014	Yes	41	12.5	0.86	13.4	4.67	11.8	209.3	sand/gravel	
D015	61.53667	160.25235	5/26/2014	Yes	1	5.8	0.88	6.7	2.80	12.0	210.3	sand/gravel	
D019	61.53534	160.22148	5/26/2014	No	0	5.8	0.96	6.8	3.10	11.8	210.3	sand/gravel	
D021	61.53578	160.22578	5/27/2014	No	0	10.8	1.08	11.9	4.05	11.8	207.9	sand/gravel	
D023	61.53599	160.24935	5/27/2014	No	0	7.4	1.07	8.5	4.62	11.7	205.6	sand/gravel	
D024	61.53353	160.25507	5/27/2014	Yes	26	6.2	1.07	7.3	2.97	11.7	203.5	sand/gravel	

Appendix C. Summary of data associated with each station sampled for rainbow smelt eggs near Kalskag, 2014.

Station	Latitude (NAD83)	Longitude (NAD83)	Date	Eggs Present	Number of Eggs	Observed Depth (ft)	Stage Correction (ft)	Corrected Depth (ft)	Water Velocity (ft/sec)	Water Temp (°C)	Specific Conductance (microS/cm)	Substrate Classification	Distance Sampled (ft)
D030	61.52861	160.27490	5/27/2014	Yes	15	8.6	1.28	9.9	3.21	11.7	204.4	sand/gravel	
D033	61.53485	160.19243	5/28/2014	No	0	5.2	1.08	6.3	2.58	11.9		sand/gravel	
D034	61.53366	160.20149	5/28/2014	No	0	6.7	1.08	7.8	2.17	11.7		sand/gravel	
C001A	61.53040	160.29538	5/28/2014	Yes	5	5.8	1.09	6.9	2.53	12.2	207.3	sand/gravel/cobble	
C002A	61.53232	160.30156	5/28/2014	No	0	4.3	1.13	5.5	1.80	12.3	207.3	sand/gravel/cobble	
C005A	61.53670	160.31411	5/28/2014	No	0	6.3	1.15	7.5	2.16	12.2	207.8	sand/gravel/cobble	
C017	61.53762	160.23338	5/25/2014	Yes	43	13.2	0.60	13.8	3.21	11.5	209.7	sand/gravel/cobble	200
D008	61.53640	160.23558	5/26/2014	Yes	40	9.8	0.81	10.6	4.21	11.6	205.4	sand/gravel/cobble	
D028	61.53034	160.28649	5/27/2014	Yes	132	4.4	1.16	5.6	3.18	11.9	209.9	sand/gravel/cobble	
A017	61.53422	160.31284	5/24/2014	No	0	13.5	0.26	13.8	4.31	11.5	205.5		20
A019	61.53690	160.31444	5/24/2014	No	0	2.6	0.26	2.9	1.25	12.1	210.1		20
A020	61.53481	160.23766	5/24/2014	No	0	2.1	0.32	2.5	1.45	11.7	201.6		20
A021	61.53492	160.23782	5/24/2014	No	0	3.2	0.29	3.5	1.94	11.7	200.7		35
A022	61.53782	160.24655	5/25/2014	No	0	2.8	0.79	3.6	1.19	12.1	210.9		18
B041	61.53419	160.24417	5/24/2014	No	0	2.5	0.42	3.0	0.94	11.7	200.7		10
C001	61.53478	160.23972	5/24/2014	No	0	1.9	0.40	2.3	0.87	11.4	200.9		
C002	61.53504	160.23972	5/24/2014	No	0	3.3	0.29	3.6	1.74	11.4	200.9		
C003	61.53455	160.24274	5/24/2014	No	0	2.6	0.42	3.1	1.38	11.6	200.8		
C004	61.53473	160.24274	5/24/2014	No	0	3.3	0.42	3.8	1.76	11.5	200.6		
C005	61.53788	160.24524	5/25/2014	No	0	3.3	0.54	3.9	2.33	11.9	210.5		50
C007	61.53646	160.24734	5/25/2014	Yes	16	8.2	0.62	8.9	4.73	11.5	206.4		200

Appendix D

Biological Data from Rainbow Smelt Adults Sampled in 2014

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Appendix D. Length, body weight and gonad weight for female rainbow smelt captured near Kalskag during 2014.

Station	Latitude	Longitude	Date	Time	Method	Fork Length (mm)	Weight (gm)	Sex	Gonad Weight (mm)	Gonadosomatic Index
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	244	127.9	F	30.6	0.314
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	238	114.5	F	29.5	0.347
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	222	78.2	F	15.4	0.245
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	250	125.9	F	35.1	0.387
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	210	85.1	F	24	0.393
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	200	56.9	F	8.1	0.166
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	200	62.2	F	13.3	0.272
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	204	58.4	F	5.1	0.096
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	205	61.5	F	6.4	0.116
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	218	92.1	F	21.4	0.303
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	233	90.1	F	17.6	0.243
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	216	78.9	F	15.1	0.237
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	198	64.1	F	13.8	0.274
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	212	85.4	F	19.2	0.290
A003	61.41657	160.59659	5/21/2014	18:57	Dip Net	203	58.9	F	6.2	0.118
various			5/22/2014		Dip Net	243	107.4	F	16.7	0.184
various			5/22/2014		Dip Net	221	96.2	F	23.1	0.316
various			5/22/2014		Dip Net	227	94.3	F	7.6	0.088
various			5/22/2014		Dip Net	232	115.5	F	25.6	0.285
various			5/22/2014		Dip Net	218	103.4	F	22.2	0.273
various			5/22/2014		Dip Net	219	91.8	F	21.9	0.313
various			5/22/2014		Dip Net	228	96.4	F	22.6	0.306
various			5/22/2014		Dip Net	253	134.2	F	31.7	0.309
various			5/22/2014		Dip Net	240	124.3	F	32	0.347
various			5/22/2014		Dip Net	252	147.2	F	32.3	0.281
various			5/22/2014		Dip Net	243	116.6	F	26.2	0.290
various			5/22/2014		Dip Net	230	113.1	F	26.4	0.304
various			5/22/2014		Dip Net	220	93.9	F	21.3	0.293
various			5/22/2014		Dip Net	255	173.7	F	41	0.309
various			5/22/2014		Dip Net	229	99.3	F	19.9	0.251
various			5/22/2014		Dip Net	220	87.9	F	19.7	0.289
various			5/22/2014		Dip Net	228	80.7	F	8.3	0.115
various			5/22/2014		Dip Net	222	102.8	F	19.9	0.240
various			5/22/2014		Dip Net	220	86.7	F	18	0.262
various			5/22/2014		Dip Net	239	125.1	F	26.5	0.269
various			5/22/2014		Dip Net	228	113.7	F	26.5	0.304
various			5/22/2014		Dip Net	234	96.9	F	15.9	0.196