Iliamna Lake Spawning Ground Habitat Assessment and Data Access

Final Report to the Bristol Bay Regional Seafood Development Association

December 2014

Prepared by:

Jason S. Ching, Curry J. Cunningham, and Thomas P. Quinn

School of Aquatic and Fishery Sciences

University of Washington Box 355020

Seattle, WA 98195

Background

The Kvichak River system is Bristol Bay's largest in lake area, number of sockeye populations, and annual spawning abundance. The system showed dramatic cycles in abundance with a 5-year period through the middle of the 20th century but then experienced several years of weak returns and more recently has again demonstrated strong sockeye salmon production. Given its vast size and capacity to dominate bay-wide returns, the issues of appropriate escapement goals, reasons for variable performance in the past, and prospects for the future under warming conditions make it imperative that the fundamental basis for production – spawning ground habitat – be fully understood. Moreover, the basin has been at the epicenter of possible large-scale mineral development with associated transportation corridors, infrastructure, and other activities, which would constitute a threat to salmon production. Regardless of whether a particular project (e.g., Pebble Mine) comes to pass or not, it is likely that at some future time there will be increased human development in the basin. However, our understanding of the Kvichak system is seriously limited. Specifically, there has been no assessment of spawning ground habitat since the work in the 1960s by the US Fish and Wildlife Service.

The US Fish and Wildlife report by Demory and co-authors (1964) listed 94 spawning sites in the Kvichak River basin, 6 of which were not considered to support salmon populations. The other sites support spawning sockeye salmon, including beaches on islands with wind-driven surface water flow, mainland beaches with groundwater flow, small streams, large rivers, and spring-fed ponds. For each site the latitude and longitude were reported, along with information on total length (for rivers), length accessible to salmon, area suitable for salmon, average width and depth, gravel composition, timing of occupancy, other fish species, and other features such as presence of shelter for small boats, personal use fisheries, wildlife, vegetation, etc. That report was a remarkable accomplishment, but it has five substantial drawbacks. First, neither the sampling methods nor the data that were used to compute the averages were reported. This is critical if past and current conditions are to be compared to conditions in the future. Second, the report is now 50 years old and conditions may have changed at one or more sites during this period. Indeed, there are indications that some of the streams have changed their course in significant ways and the naming of some streams is ambiguous. Third, the report is out of print and so not accessible to most people. Even if people had copies of the report, the information would be much more useful and user-friendly if it were in electronic format, and presented in an intuitive manner. Fourth, the descriptions of the spawning grounds are not linked to information on relative abundance of salmon, as might be indicated by the aerial surveys that were conducted by FRI and ADF&G. The report is also not linked to the ADF&G database on the presence of different fish species, known as the Anadromous Waters Catalog: https://www.adfg.alaska.gov/sf/SARR/AWC/). Fifth, the report has no information on the lake itself, and the historical information on temperature and other features collected by FRI is equally inaccessible to the public.

Purpose

We proposed first to use modern techniques to re-survey selected streams assessing gradient, discharge, water chemistry, temperature, sediment size, and other physical features essential to salmon spawning. Surveys were to initially focus on the spawning areas that would be most directly affected by mining and road development. This assessment would essentially update the 1964 US Fish and Wildlife Service report by Demory, in parallel to a similar report put together for the Wood River system by Mariott in 1964. Our secondary but equally important goal was to take the information from both Demory's report and Marriott's report, digitize them, and make them publicly available on a University of Washington's Alaska Salmon Program website, along with the data collected in this project and other FRI data on the ecology of this system, link it to ADF&G data with their permission, so that members of the Bristol Bay community have full access to this otherwise unavailable, but exceptionally valuable information.

Accomplishments and Survey Methods

During the 2013 field season we conducted habitat surveys on 9 streams located at the east end of Iliamna Lake (Figure 1), between Chinkelyes Creek (the main tributary of the Iliamna River) and Canyon Creek, which lies east of Iliamna Village, and in 2014 we conducted surveys on an additional 10 streams, eastward beyond Iliamna Village to Lower Talarik Creek, so that all streams (including two that are not named) from the Iliamna River to Lower Talarik Creek have been surveyed (Figure 2). These were selected as high priority because, as noted in the proposal, this is the region of the system most likely to be affected by any road system from Cook Inlet (e.g., Williamsport or Iniskin Bay) into Iliamna Lake. For each of the surveys we first travelled as far upstream as time allowed (average = 4.2 km) and fixed the location with a GPS. From this point we divided the distance to the stream's mouth into four evenly spaced points along the stream and conducted what we termed "full surveys" at each of these four sites. Using a Laser Technology – Impulse laser rangefinder we acquired wetted width measurements by positioning the rangefinder at the stream's edge, ensured that the instrument was vertically level, and then took a measurement pointed at the stream edge at the opposite side indicating horizontal distance in meters. We took this measurement a minimum of three times to promote accuracy. We also used the rangefinder to measure gradient by positioning the rangefinder just so it was touching the surface of the water at the edge, ensuring that the rangefinder was vertically level, and then shooting at a reflector of equal height roughly 20-30 m downstream. The person holding the reflector also maintained a vertically level position at the surface of the water at the edge. This measurement was taken a minimum of three times to promote accuracy and yielded slope in % or grade.

To record water velocity and depth we first spanned a measuring tape directly across the stream at the survey site, allowing us to take measurements at specific increments across the stream. We used a hand-held Swoffer Model 2100 current velocity meter to take measurements where possible (measurements were sometimes hindered by vegetation, extremely deep areas and areas too shallow). Starting at the bank on river left and ending at the opposite bank (river right), we first recorded the depth in meters, using that depth measurement the instrument would be lowered to 60% of the recorded depth where an average velocity would be recorded meters per second. Such measurements were recorded in 0.5 m increments across the stream unless the stream's wetted width exceeded 10 m, in which case measurements were recorded in 1.0 m increments. Discharge in m^3/sec was calculated by combining cross-sectional area from width and depth measurements and mean water velocity. Dissolved oxygen in parts per million and temperature in degrees Celsius were recorded in 2014 surveys using a YSI DO200A Dissolved Oxygen Meter. The dissolved oxygen probe was held underwater and gently waved side-to-side to circulate water around the probe until stable readings for both temperature and dissolved oxygen were given (ca. 3-5 minutes). Water temperature in degrees Celsius, conductivity in millisiemens per centimeter and pH were recorded using a Yellow Springs Instruments 600XLM

Multi-Parameter Water Quality Monitor with an installed pH sensor. The instrument was launched prior to heading into the field (i.e., initialized by a computer), at which point it recorded measurements every 2 seconds. The instrument was submerged in the main channel of the stream at the survey site for 5 minutes to allow for enough time for readings to stabilize (i.e., to equilibrate with ambient conditions).

Substrate particle size distribution was estimated using calipers to measure the median axis in millimeters of 50 randomly sampled particles (gravel and rocks) on the substrate surface of the wetted stream at the survey section. The person measuring substrate particles would attempt to cover the entire width of the stream to sample representative substrate at the survey site. In addition, site-specific characteristics including canopy cover, large woody debris, substrate embeddedness, bank vegetative protection and bank stability were visually assessed and given a value on a 0-10 scale (0 indicating absence of vegetation along the bank, large woody debris, canopy cover, silt among the substrate or an unstable bank and 10 indicating full coverage and very high stability). Similarly, turbidity was assigned a rating from the following choices "clear, opaque, slightly turbid, stained, turbid." Finally, at each full survey location, photographs were taken to supplement the data from ground-level and also from a small, remotely-operated drone equipped with a GoPro camera.

In addition to the full surveys at four sites along each stream, the reach between each pair of sites was further divided into approximately 5 evenly spaced locations (i.e., 20 samples in total in each stream, distributed over the distance from the upper extent of the survey to the stream mouth). At each of these sites, gradient was measured using the laser rangefinder and stream width was measured with the rangefinder or meter tape, depending on the size of the stream. We also noted the observed presence or absence of sockeye salmon and resident fish at the time of the survey. Our focus was primarily on physical measurements of the streams and our time constraints did not permit us to quantitatively assess fish populations. Thus the failure to note the presence of resident fish should not be taken as evidence of the absence. All survey locations were fixed as GPS points. In addition to the stream measurements and observations, continuous temperature loggers were deployed at each of the surveyed streams. These temperature loggers were retrieved during the 2014 field season and in many cases re-deployed to obtain an additional year of data, to be retrieved in 2015. We hope to maintain as many of these recording stations as possible in future years.

In accordance with the proposal, we have also made a summary of the US Fish and Wildlife Service's Spawning Ground Catalog for the Kvichak River system and the Stream Catalog of the Wood River Lake system available to the public alongside our own survey data from the 2013 field season. These data are presented in the form of an interactive map and sortable table on a project website: http://depts.washington.edu/uwasp/wordpress/sgc/.

Summary of Findings

Many of the streams visited in these surveys had not been surveyed by FRI for decades, and the data we collected are therefore of great value. In general, the streams varied greatly in physical and chemical aspects, and the primary goal of our ongoing work will be to fully understand the patterns of this variation, and the consequences for sockeye salmon and other fishes in the basin. The stream survey data are undergoing initial statistical analyses and will be subsequently examined in more detail to assess first the similarities and differences from those reported by Demory. Differences could be a result of actual changes in the streams themselves, and there are indications that some (notably Canyon Creek and Chekok Creek) have undergone notable changes in channel resulting from stream capture. In other cases differences might result from the different sampling protocols, areas of the stream where the surveys occurred, or conditions on the date of the survey. Features such as gradient are unlikely to have changed and the modern methods that we used are likely to be more accurate, as early surveys may have relied on topographical maps whereas we used a laser rangefinder. On the other hand, if the early surveys used maps they probably included longer segments of the streams, including steep upper sections that time constraints prohibited us from surveying on foot. Similarly, our GPS coordinates are likely more accurate than early, map-based estimates of locations, and our use of electronic meters to measure water velocity would be much more accurate than any equipment available to the other surveyors. Finally, we collected water chemistry data, which the earlier study did not, and continuous temperature records, which were not possible in the early years.

Our analyses are focusing on attributes of the streams that can be related to sockeye salmon abundance and density, estimated from ADF&G aerial surveys, and attributes that might make them sensitive to development. For example, high gradient, high velocity streams that would be crossed by roads would likely be more vulnerable than lower gradient streams, and streams with little buffering capacity would be more vulnerable to low pH events than streams in areas with geological features that buffer the chemistry. In addition, stream chemistry may be related to features of primary production (i.e., algae) and secondary production (insects) that would affect density or growth of rainbow trout, grayling, Dolly Varden, and juvenile coho and Chinook salmon.

Analyses to date have indicated many very substantial differences between our data and those in the Demory report in average values for important stream features such as gradient and substrate (gravel size). Some of these differences are probably consequences of methodologies rather than actual changes in stream condition. For example, it is unlikely that the gradient of rivers changed over large distances because it is related to local geology, so survey methods were almost certainly the cause of the discrepancy. Differences in gravel size are also noteworthy, and this is a very important feature of streams. Many reviews have indicated the critical role that gravel composition makes in survival of salmon and trout embryos (Chapman 1988; Jensen et al. 2009), and other aspects of the ecology of fishes in streams (Chapman et al. 2014). Thus the data that we have, with replicable methods, are an essential baseline against which to compare any future changes, and with which we can examine patterns in the distribution and density of salmon. The early report had no data at all on water chemistry, and certain kinds of land-use activities can alter chemistry, thus the baseline data that we have (prior to significant development) are of great value.

Interpretation, Conclusion, and Future Directions

The purpose of this project was not to test a specific, narrowly framed scientific hypothesis, nor was it designed to modify fisheries management practices or processing methods to yield an immediate economic return to the commercial fishing and processing community in Bristol Bay. Rather the purpose was to obtain basic information on the physical habitat on which sockeye salmon of the Kvichak River system depend for successful breeding, and to provide that information, combined with historical information from decades past, to the region's community for their use. Our results highlight the diversity of streams used by sockeye salmon in all the important physical variables we measured, from things obvious to the naked eye such as width, depth, and gradient, to less obvious but equally important features such as temperature (mean and seasonal variation) and chemistry. The diversity of stream conditions is part of what buffers this and other parts of the Bristol Bay sockeye salmon complex against environmental variation that results in poor survival in one set of habitats or another (Hilborn et al. 2003; Greene et al. 2010; Schindler et al. 2010). The dispersal of risk across the complex mosaic of salmon habitat types exhibited in the Kvichak watershed, is likely to be a key attribute facilitating persistence of salmon in the face of future environmental variability and rapid climate change. Future analyses, mentioned above, will determine the ways in which streams with certain attributes track each other in abundance or diverge in abundance (e.g., Stewart et al. 2003), and these kinds of correlations are essential if we are to understand the patterns of production in the system as a whole.

In addition to the scientific value of the data collected, the proposal had two other important goals. The first was to make data freely available to the public, and especially the communities in the Bristol Bay and Kvichak system. The website, detailed in this report, makes these kinds of data available for the first time, in an explicit effort to help people learn more about the lake system that yields so much from both commercial and subsistence perspectives. We have endeavored to make the links easy to follow, and will be prepared to make modifications as needed to improve user-friendliness. The other goal was to provide crucial information on the contemporary condition of streams that might be affected by a road system or other forms of human development. The nature of the early (Demory) report was such that any habitat degradation from human activity (e.g., failure of an unpaved road, sediment modification from a dam or culvert, etc.) could not be reliably compared to pre-development condition. This problem results from the inadequate description of the methods in the early report (that is, it would be impossible to replicate) and also from the passage of time, as the streams may have changed during the past five decades. One could not distinguish between the two processes, so the report would have little value in helping resolve present-day questions regarding habitat impact. On the other hand, the data we have collected data are both replicable and contemporary. That is, if there were to be any concern about alteration of the physical stream habitat or chemistry, people could go to the stream and with confidence collect data in a similar manner to those we collected, and make any comparisons deemed necessary.

In the immediate future (i.e., during the remainder of the extended contract period) we plan to subject the data to multivariate analyses to look for clusters of streams with similar and chemical physical features. These analyses incorporate many kinds of variables and can determine the groups of streams that are most similar and most different, and the features that they tend to have in common or in which they differ. These clusters of streams, produced by statistical analyses, will then be examined with respect to spatial patterns (are they all in certain parts of the lake, or are similar streams not necessarily close to each other?). We also plan determine whether patterns of sockeye salmon abundance and resident fish distribution match these features. When we have examined these data in sufficient detail to determine the important patterns, we hope in future years to be able to carefully examine the island and mainland beaches where sockeye salmon spawn. These beach populations have, in the past, been very large contributors to the system as a whole but they seemed to show rather different patterns of abundance and dynamics compared to small streams and large rivers (Blair 1989; Stewart et al. 2003). Different survey methods will need to be devised to consistently and accurately obtain relevant physical habitat data but information from the Demory report, combined with information reported by Kerns and Donaldson (1968) and Leonetti (1996, 1997), should provide guidance in this regard.

Acknowledgments

We gratefully acknowledge the Bristol Bay Regional Seafood Development Association for providing the financial support for this report, and in so doing, for recognizing the essential role that physical habitat plays in producing the salmon that support the human and ecological communities of the region. We thank the Pedro Bay Corporation for permission to access their land during the conduct of the sampling, and the many individuals who were so hospitable to us in many ways. The field work itself was physically demanding and was the primary responsibility of Curry Cunningham and Jason Ching, with many outstanding field assistants, notably Cyril Michel, Morgan Bond, Hannah Stapleton, and Rachel Hovel; we thank them all.

References

Blair, G. R. 1989. Site-specific differences in selected characteristics of sockeye salmon (*Oncorhynchus nerka*) as evidence for natal homing in the Kvichak River system, Alaska. University of Washington, Seattle.

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117:1-21.

Chapman, J. M., and coauthors. 2014. Clear as mud: A meta-analysis on the effects of sedimentation on freshwater fish and the effectiveness of sediment-control measures Water Research 56:190-202.

Demory, R. L., R. F. Orrell, and D. R. Heinle. 1964. Spawning ground catalog of the Kvichak River system, Bristol Bay, Alaska. U.S. Fish and Wildlife Service, 488, Washington, D.C.

Greene, C.M., Hall, J.E., Guilbault, K.R., and Quinn, T.P. 2010. Improved viability of populations with diverse life history portfolios. Biology Letters 6: 382-386.

Hilborn, R., Quinn, T.P., Schindler, D.E., and Rogers, D.E. 2003. Biocomplexity and fisheries sustainability. Proceedings of the National Academy of Sciences 100: 6564-6568.

Jensen, D. W., E. A. Steel, A. H. Fullerton, and G. R. Pess. 2009. Impact of fine sediment on egg-to-fry survival of Pacific salmon: a meta-analysis of published studies. Reviews in Fisheries Science 17:348-359.

Kerns, O. E. J., and J. R. Donaldson. 1968. Behavior and distribution of spawning sockeye salmon on island beaches in Iliamna Lake, Alaska. Journal of the Fisheries Research Board of Canada 24:485-494.

Leonetti, F. E. 1996. Habitat attributes, sockeye salmon spawning behavior, and redd site characteristics at island beaches, Iliamna Lake, Alaska. Master's thesis. University of Washington, Seattle.

Leonetti, F. E. 1997. Estimation of surface and intragravel water flow at sockeye salmon spawning beaches in Iliamna Lake, Alaska. North American Journal of Fisheries Management 17:194-201.

Marriott, R. A. 1964. Stream catalog of the Wood River lake system, Bristol Bay, Alaska. U.S. Fish and Wildlife Service 494, Washington, D.C.

Schindler, D.E., Hilborn, R., Chasco, B., Boatright, C.P., Quinn, T.P., Rogers, L.A., and Webster, M.S. 2010. Population diversity and the portfolio effect in an exploited species. Nature 465: 609-612.

Stewart, I. J., R. Hilborn, and T. P. Quinn. 2003. Coherence of observed adult sockeye salmon abundance within and among spawning habitats in the Kvichak River watershed. Alaska Fishery Research Bulletin 10:28-41.

Wolman, M. G. 1954. A method of sampling coarse river-bed material. Transactions of the American Geophysical Union 35:951-956.

Figures

Figure 1. Map of Iliamna Lake showing streams surveyed in the eastern part of the lake.

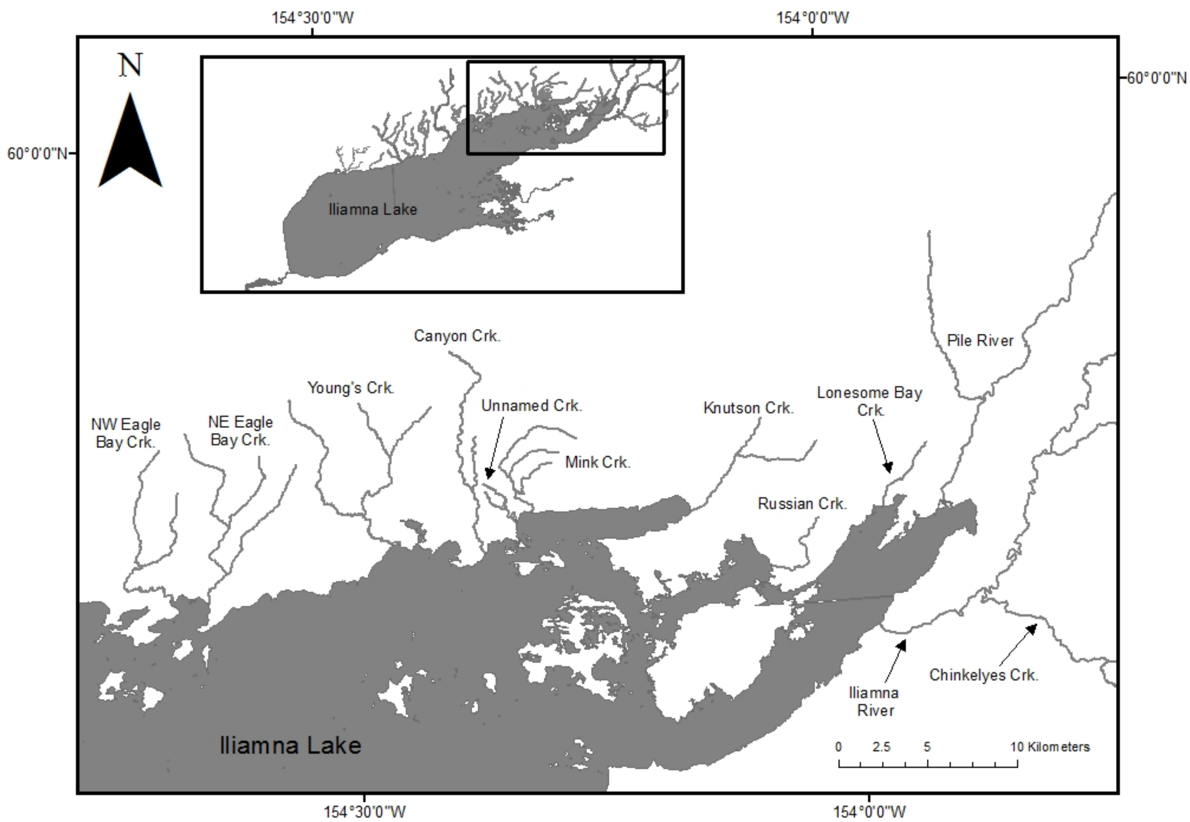
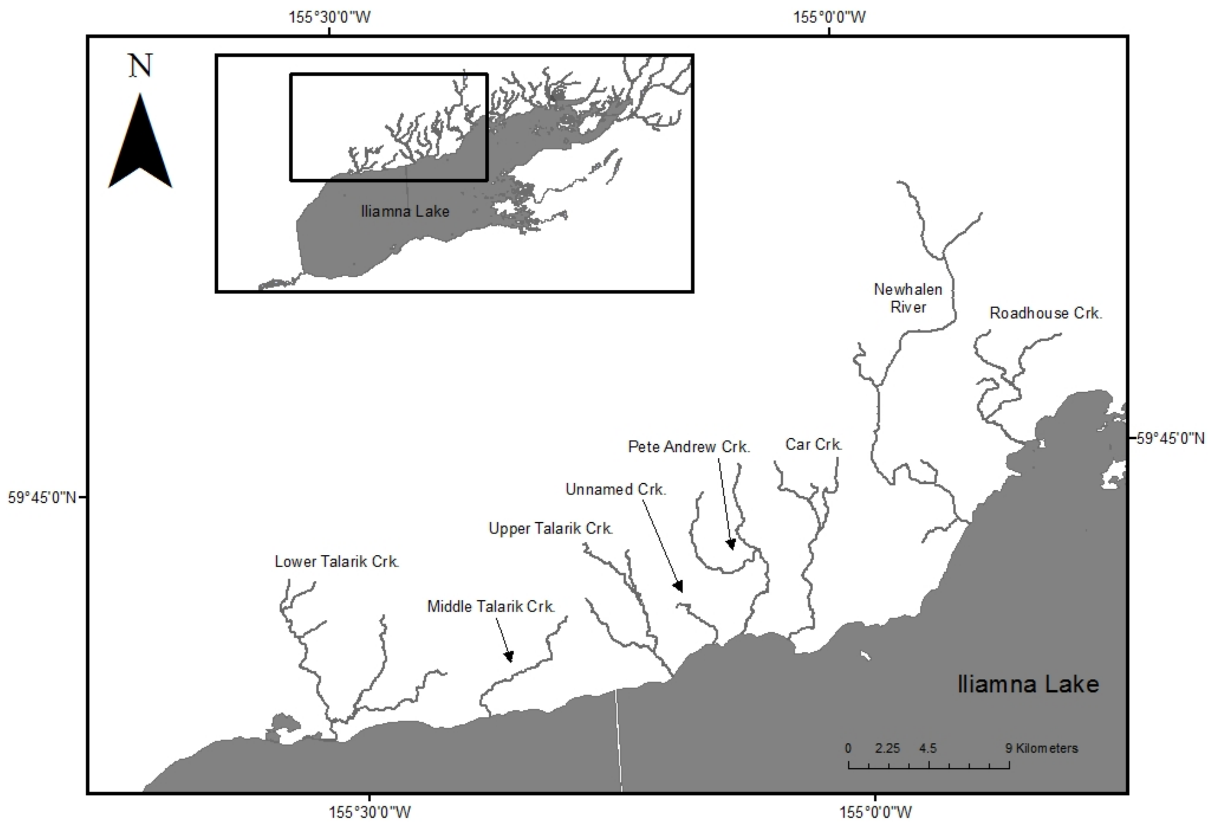


Figure 2. Map of Iliamna Lake showing streams surveyed in the northwestern part of the lake.



Tables

Table 1. Summary of physical conditions in the streams surveyed in 2013 and 2014, including the average size of gravel, discharge, distance surveyed, gradient, depth and width of the wetted channel on the survey date. Streams are ordered geographically, from Chinkelyes Creek, a tributary of the Iliamna River, around the north side of Iliamna Lake, moving westward to Lower Talarik Creek. The unnamed creeks were west of Pete Andrew Creek and Mink Creek and are listed next to those creeks.

Stream Name	Substrate (mm)	Discharge m^3/s	Distance (km)	Gradient (% Slope)	Depth (m)	Width (m)
Chinkelyes Creek	46.1	2.81	2.58	-0.30	0.42	20.34
Iliamna River		8.04	6.97	-0.04	0.56	64.41
Pile River		12.68	4.63	-0.10	0.49	39.63
Lonesome Bay Creek	102.8	0.53	1.33	-2.91	0.24	6.18
Russian Creek	106.7	0.16	3.60	-2.08	0.14	4.28
Knutson Creek	134.7	2.67	2.38	-1.89	0.38	13.44
Mink Creek	29.6	0.05	2.25	-0.90	0.16	3.65
Unnamed creek	24.1	0.22	1.70	-0.29	0.19	5.58
Canyon Creek	38.9	2.91	5.00	-0.77	0.33	14.57
Young's Creek	22.9		4.75	-0.29		9.41
NE Eagle Bay Creek	39.5	0.39	4.96	-0.69	0.21	5.34
NW Eagle Bay Creek	24.8	1.09	4.52	-0.28	0.60	5.95
Roadhouse Creek	34.9	0.68	5.00	-0.40	0.39	4.06
Car Creek	22.9	1.56	4.83	-0.55	0.59	11.63
Pete Andrew Creek	28.5	0.56	5.84	-0.59	0.21	6.72
Unnamed creek	24.9	0.15	2.28	-0.69	0.24	2.22
Upper Talarik Creek	38.7	4.19	6.95	-0.70	0.97	18.39
Middle Talarik Creek	23.2	0.40	4.75	-0.58	0.19	7.37
Lower Talarik Creek	36.9	2.20	5.40	0.56	0.30	22.29

Table 2. Summary of physical conditions in the streams surveyed in 2013 and 2014, on the given survey dates: average conductivity (in µS/cm), average water temperature, and median pH. Streams are ordered geographically, from Chinkelyes Creek, a tributary of the Iliamna River, around the north side of Iliamna Lake, moving westward to Lower Talarik Creek. The unnamed creek was west of Pete Andrew Creek.

Stream Name	Survey date	Conductivity	Temp °C	pH
Chinkelyes Creek	8/28/2013	12.85	11.00	6.78
Iliamna River	8/29/2013	15.19	9.23	6.59
Pile River	8/29/2013	17.90	8.41	6.74
Lonesome Bay Creek	8/14/2013	18.36	9.23	7.03
Russian Creek	8/11/2013	57.71	15.08	7.58
Knutson Creek	7/28/2013	14.59	11.19	
Mink Creek	7/31/2013	32.49	9.56	6.79
Canyon Creek	8/17/2013	24.13	11.33	7.13
Young's Creek	8/2/2014	43.51	12.98	7.62
NE Eagle Bay Creek	7/18/2014	54.81	9.88	7.83
NW Eagle Bay Creek	7/19/2014	67.39	12.40	7.62
Roadhouse Creek	7/17/2014	48.03	16.77	7.46
Car Creek	7/21/2014	36.39	15.96	7.53
Pete Andrew Creek	7/22/2014	31.83	14.31	7.46
Unnamed creek	7/23/2014	36.00	11.86	7.30
Upper Talarik Creek	7/26/2014	51.02	13.23	7.66
Middle Talarik Creek	7/24/2014	29.11	13.32	7.76
Lower Talarik Creek	7/27/2014	48.14	17.22	8.22

Table 3. Recent annual average surface water temperatures at the five sampling sites in the east end of Iliamna Lake, and the estimated dates of annual ice-off, based on communication with residents in Iliamna, Pedro Bay, Igiugig, and Kokhanok. These data are selected to illustrate the range of temperature conditions in the lake; the data collected include temperature at depth to ca. 50 m.

Year	Surface water temp. °C	Ice out (day of the year)	Ice out (date)
2004	14.22	115	24-Apr
2005	14.85	119	29-Apr
2006	10.37	140	20-May
2007	11.05	142	22-May
2008	12.09	139	18-May
2009	10.53	142	22-May
2010	9.20	139	19-May
2011	10.31	140	20-May
2012	9.38	142	21-May
2013	10.49	136	16-May
2014	11.45	121	1-May

Table 4. Average July 2014 water temperatures for streams with recovered temperature loggers, as examples of summer temperature variation. Raw data were collected continuously over the year.

Stream Name	Temp. °C
Chinkelyes Creek	12.22
Pile River	10.26
Lonesome Bay Creek	9.39
Mink Creek	10.62
Unnamed Creek (West of Mink Creek)	6.99
Roadhouse Creek	14.17

Table 5. Average dissolved oxygen (ppm) for streams surveyed in 2014 on the survey dates.

Stream Name	Date	Dissolved Oxygen
Young's Creek	8/2/2014	10.34
NE Eagle Bay Creek	7/18/2014	11.88
NW Eagle Bay Creek	7/19/2014	11.17
Roadhouse Creek	7/17/2014	9.74
Car Creek	7/21/2014	10.80
Pete Andrew Creek	7/22/2014	10.62
Unnamed Creek (West of Pete Andrew Creek)	7/23/2014	11.17
Upper Talarik Creek	7/26/2014	10.49
Middle Talarik Creek	7/24/2014	11.36
Lower Talarik Creek	7/27/2014	10.42

Appendix: Contractual Deliverables and Completion of Tasks

All deliverables stated in the contract have been fulfilled. Please see below for details.

1) We proposed to re-survey selected spawning sites, beginning with those in the eastern end of the lake, along the corridor proposed for road access, to obtain basic physical habitat information and water chemistry.
    a. Over the course of the two field seasons we collected physical habitat information on 19 streams between Chinkelyes Creek, a tributary of the Iliamna River and Lower Talarik Creek. Our surveys included all streams listed in the Demory report that are along the corridor proposed for road access with the exception of the Newhalen River, and included an additional two unlisted creeks. The Newhalen River is much too wide, deep and fast to be surveyed with our methods.
2) We proposed to document the field protocols so that others could replicate the methods in the future, and report and archive the data in accessible medium. The second part of the study would be to set up a web-based information system with the data from the Demory report and current FRI data that could be searched from a map of the lake basin or a drop-down list of spawning sites.
    a. Field protocols and methods for each of the various measurements collected for the physical habitat surveys were documented and are available for review on the website along with the data collected. Data are presented in summary format in the form of an interactive map of the lake basin and a detailed, sortable and searchable table of the data is also readily accessible on the website. The methods can be found on its own webpage, listing the materials, equipment used, and methods for the surveys, as well as in this report (above). Data from the Demory report as well as the Marriott report (stream catalog of the Wood River system) have been converted to electronic format and made into a sortable and searchable table on the website. This website is currently active and is located at: http://depts.washington.edu/uwasp/wordpress/
3) Primary list of data to be taken for each site:
    a. Stream width and depth along transects at standard intervals
        i. We collected stream wetted width measurements at approximately 20 evenly spaced intervals along the length of the survey reach. Cross-sectional depth measurements were taken at 4 evenly spaced intervals along the length of the survey reach.
    b. Gravel size, based on surface particle measurements and bulk samples
        i. We measured substrate particle size for 50 particles at 4 evenly spaced intervals along the length of the survey reach.
    c. Gradient and presence of woody debris
        i. We measured gradient at approximately 20 evenly spaced intervals along the length of the survey reach. We noted and characterized the presence or

absence of woody debris at 4 evenly spaced intervals along the length of the survey reach.

d. Water pH and hardness
    i. Water pH was measured using a handheld water quality sonde at 4 evenly spaced intervals along the length of the survey reach. Water hardness was determined by collecting water samples at 4 evenly spaced intervals along the length of the survey reach and running titrations for obtaining concentrations of calcium carbonate at our lab.
e. Continuous temperature loggers deployed and retrieved the following year, generating temperature profiles of spawning habitat.
    i. We deployed temperature loggers at each of the streams we have surveyed. We attempted to place them in areas where they will gather data representative of the stream, avoiding side channels or areas we thought could be affected by low flow. We also took into account locations protected from debris and damaging conditions, and areas where they could be easily recovered in future seasons. We were able to successfully retrieve 6 out of the 9 temperature loggers we deployed in the 2013 season; we believe that the remaining 3 were washed out. In addition to the new locations we surveyed this year (2014) we have re-deployed temperature loggers at all previous locations we surveyed in the 2013 season. The retrieved data has been made into temperature profiles which are available in the form of line graphs on the website.
f. We will measure discharge at base flow with water velocity meters and measurements of cross-sectional area in many of the streams that are along the proposed transportation corridor and most likely affected by development activities.
    i. Water velocity measurements and measurements of cross-sectional area were taken at 4 evenly spaced intervals along the length of the survey reach.