Assessment of fish and wildlife presence near two river instream energy conversion devices in the Kvichak River, Alaska in 2014

Prepared for

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Assessment of fish and wildlife presence near two river instream energy conversion devices in the Kvichak River, Alaska in 2014

by

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EXECUTIVE SUMMARY

Two river instream hydrokinetic (RISEC) devices were installed in the Kvichak River, Alaska in 2014 to demonstrate the ability to generate hydroelectric power. Fish and wildlife were monitored nearby to describe their presence and to document any negative effects from the devices. Fish were monitored using underwater video cameras and lights mounted to each device; wildlife (birds and mammals) were monitored using shore-based surveys by trained biologists and technicians. Both devices were installed near the village of Igiugig, submerged in the river until sitting on the river bottom, and operated intermittently in August and September.

Fish were present at each device and were seen travelling upstream, travelling downstream, and milling. Most observed fish were salmon and salmonids (*Oncorhynchus* spp.) and moved freely around each device. No fish were detected moving through the turbine part of the larger device, which was manufactured by the Ocean Renewable Power Corporation. At the smaller device, manufactured by Boschma Research, Inc., one lamprey (*Lampetra* spp.) was detected moving downstream through the part of the device housing the turbine. Overall, salmon were clearly less abundant at the devices than along the edges of the river nearby and showed no negative effects from the devices. Wildlife consisted almost entirely of birds, had no contact with or negative effects from the devices, and showed no behavioral changes when nearby.

The fish monitoring design was also meant to test the ability to use underwater cameras to monitor fish in the type of conditions found on the Kvichak River. Cameras were able to detect fish from 10 to 15 feet away, depending on water clarity; this range allowed coverage of 1/3 of the ORPC device and of the entire entrance and exit of the BRI device. In the daytime, ambient light was sufficient for fish detection; at night, lights placed nearby allowed video recording to continue with no loss of effectiveness. All cameras and lights were fixed directly to the devices in a design finalized once on site, and were powered from shore. Cameras and lights were able to be started within 1 to 12 hours after deployment of each device, and operated effectively thereafter with no breakdowns.

Camera images were recorded on shore at a temporary recording station, where footage could be viewed in real time during daily site visits by trained technicians. Imagery was then transferred to a laptop computer and reviewed nearby in Igiugig. A subsample of 10 minutes was reviewed from each hour of video footage (from each camera); most of these 10-minute blocks were able to be reviewed within two days of original recording. Video imagery was recorded during all operation time by the ORPC device and 72% of the operating time by the BRI device.

Overall, fish were seen at rates of less than one fish per 10-minute block of video reviewed at each device. This rate was likely a function of the device placement (relatively far offshore, in water that was deeper and faster than other parts of the river channel), and timing (after the peaks of both the juvenile and adult sockeye salmon [*O. nerka*] run). More detailed aspects of fish presence and behavior are reported below.

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INTRODUCTION

Two river instream conversion (RISEC) devices were operated underwater on the Kvichak River, near the village of Igiugig, Alaska, during a demonstration period in 2014. The ultimate goal of the demonstration was to test the efficiency and feasibility of the devices and gather information in preparation for a 5-year pilot license application to be submitted to the Federal Energy Regulatory Commission (FERC). Permission to operate the devices in 2014 required a Fish Habitat Permit (a “Title 16” permit) from the State of Alaska, Department of Fish and Game (ADF&G), granting permission for project activities in anadromous streams (AS 16.05.841-71). For the Title 16 permit, a monitoring plan (LGL 2014) was developed in consultation with ADF&G before deployment, to monitor fish and protect their passage. Although fish were the focus of the monitoring plan, terrestrial and aquatic wildlife were also monitored near the devices.

This report describes monitoring efforts used to fulfil these requirements, including methods, fish and wildlife detections, and any detected effects (positive, negative, indifferent) on fish or wildlife from the devices. Results presented here are intended to also help refine future monitoring methods and passage protection needed during any subsequent licensing phases.

The two RISEC devices monitored in 2014 were the RivGEN Power System manufactured by the Ocean Renewable Power Company (ORPC; Portland ME) and the BRI Cyclo-Turbine™ manufactured by Boschma Research Inc. (BRI; Brownsboro AL). Detailed designs for both devices were presented in the preseason monitoring plan (LGL 2014).

OBJECTIVES

The overall goal of this study was to monitor fish and wildlife in the vicinity of the RISEC devices while assessing the viability of an underwater camera system to monitor fish. The specific objectives in 2014 were as follows:

1. Document and classify any encounters of fish and wildlife with two RISEC devices.
2. Describe behavioral responses to any encounters with the devices, as well as subsequent effects on any fish or wildlife.
3. Assess whether the devices visibly alter in-stream habitat nearby.
4. Evaluate the viability of an underwater camera system to monitor fish at the devices.

STUDY AREA

Kvichak River Landscape and Fish Resources

This project was located on the Kvichak River, near the outlet of Iliamna Lake at the village of Igiugig. The watershed flows from glacially-turbid headwater streams down into Lake Clark, then southwesterly down the Newhalen River and into Iliamna Lake, the largest lake in Alaska. The Kvichak River then drains Iliamna Lake, running 106 km to the west and emptying into Bristol Bay in southwestern Alaska (Figure 1). The entire drainage is thus large (16,830 km^2) and is characterized by two large lakes that support enormous runs of sockeye salmon (*Oncorhynchus nerka*) that drive much of the region's economy. These lakes help trap glacial sediment, allowing the Kvichak River to be a relatively clearwater stream at Igiugig. Mean annual water discharge (1968 – 1986) for the Kvichak River near Igiugig was 503 m^3/s (17,763 ft^3/s), with annual peaks in August, September, and October (USGS 2008).

The Kvichak River is one of nine main rivers producing sockeye salmon targeted in Bristol Bay commercial, subsistence, and sport fisheries. Sockeye salmon return to the Kvichak River at Igiugig from mid-June to mid-July (Figure 2). The area near the RISEC demonstration sites in 2014 is important for managing the sockeye salmon fishery; part of ADF&G's inseason management of the Kvichak sockeye salmon stock comes from data collected at the salmon counting tower located just downstream of the village of Igiugig (~2 km). The average annual count of sockeye salmon at this tower was 3 million fish from 2005 through 2014 (calculated from annual count data provided by ADF&G). The Kvichak River at Igiugig is classified as Essential Fish Habitat (EFH) for anadromous fish by NOAA (2011).

The Kvichak River also supports a variety of other fish species of important socioeconomic value, with habitat use that ranges from seasonal migration corridors to year-round presence (Table 1). In addition to the other four species of Pacific salmon (*O.* spp.) found in Alaska, these include seven non-salmon species that Krieg (2003) estimated to be harvested by at least 25% of the households in the village of Igiugig. Overall, the study area is one in which a rich assemblage of fish species results in high subsistence, sport, commercial, and socioeconomic importance to local and regional residents.

Study Site Characteristics

Both RISEC devices were anchored and submerged on the bottom of the river, at or near 2 of the 11 sites originally surveyed by Terrasond (2011) to determine suitability. The ORPC device was located between Sites 9 and 10, approximately 1,000 m downstream of the public boat launch at the village of Igiugig and 125 m downstream of the end of Flat Island (Figure 1). Estimated water depth was 5.8 m, water velocity was 1.5 to 2.5 m/s, and river bed substrate was small cobble with very coarse, coarse, and medium gravel, and no significant amounts of finer material (TerraSond 2011). Final placement was approximately 100 m off the west bank (river right when facing downstream). The top of the device was approximately 1.25 m below the surface of the water during deployment in 2014 (R. Tyler, ORPC, personal communication).

The BRI device was installed at Site 6, approximately 100 m upstream from the boat launch and 1 km upstream from the ORPC device (Figure 1). Estimated water depth was 3 m, velocity was 1.8 to 2.5 m/s, and river bed substrate was primarily small cobble and coarse gravel with a small proportion of fines (TerraSond 2011). Final placement was approximately 75 m off the south bank (river left, facing downstream) with a substrate mix that included some large cobbles (personal observation by report author MJN) in addition to the substrate documented by Terrasond in 2011. Based on water depth (3 m) minus device height (2 m), the top of the device sat approximately 1 m underwater when resting on the river bottom.

Other hydraulic and bathymetric characteristics of the Kvichak River at Igiugig were described by TerraSond (2011).

METHODS

Fish Monitoring

Fish presence near each device was monitored using underwater video cameras that recorded and stored imagery. Video recordings were reviewed to document the following events, if any:

1. The number of fish, by species, encountering the device.
2. The basic behavioral response of fish encountering the devices (e.g., attraction, avoidance, change of course).
3. Any direct contact of fish with the device turbines.
4. Any visible evidence of negative effects from a contact event, such as physical exertion, injury, or death.

Video system design

Underwater cameras used at the RISEC devices were powered from shore, where data was also then collected and stored in a digital video recorder (DVR) for analysis. Underwater lights were placed near some cameras to illuminate the area and collect video images at night. All cameras and lights were manufactured by IAS systems (North Vancouver, British Columbia). Cameras were customized SeeMate ™ color to monochrome units with a F2.9 wide angle lense. Lights were SeeBrite ™ omnidirectional model 24L-SS-LED-350. Each light had four circuit boards, each with 24 light-emitting diodes (LEDs). DVRs were 16-channel units with a frame rate of 480 pps, manufactured by Dedicated Micros (Chantilly, WA).

Five cameras and two lights were used to monitor the ORPC device (Figure 3; Photo 1). Two cameras and one light were used to monitor the BRI device (Figure 4; Photo 2) Cameras and lights were affixed directly to the devices.

Data collection and management

Underwater cameras were operated whenever the device was operating (i.e., the turbine was spinning), as well as other times when the device was installed but not operating (i.e., the turbine was not spinning). Lights were used on a portion of the nights that the device operated. Each day, a field biologist downloaded video imagery from the shoreside power station.

For review, video imagery was separated into one-hour blocks of data. Imagery was then reviewed for the first 10 minutes of each hour, from each camera. Imagery was subsampled from all hours when the devices were operating, as well as a portion of the time when the device was not operating. Most subsamples of the imagery were reviewed inseason, on site in Igiugig, to detect any undesirable effects of the devices on fish (as specified in the Adaptive Management portion of the Monitoring Plan filed with the permitting process; LGL 2014).

Any fish detected were classified by species or group (e.g., salmonids), and placed into one of the three size classes: small fish less than 125 mm long (corresponding to the size of juvenile salmon); medium fish 125 – 250 mm long (smaller than adult salmon); and large fish longer than 250 mm (the size of large adult trout and adult salmon). Thereafter, all detections were classified as follows:

1. Movement direction (downstream, upstream, milling, or undetermined);
2. Evidence of passage delay, i.e., fish struggling to pass the device;
3. Contact with the device;
4. Evidence of injury or mortality; and,
5. Any other negative impacts.

Additionally, reviewers described each fish detection event for follow-up analyses.

Datasheets and then electronic entries were reviewed for quality assurance/control (QA/QC). Video imagery was archived on hard drives.

Visual verification of camera imagery and signs of streambed scour

The original monitoring also called for an alternate method to verify imagery seen by the cameras, and to report any signs of streambed scour downstream of the devices. This alternate method was to be developed *in situ*, based on site characteristics (LGL 2014). At the ORPC device, the safest and most reliable alternate method identified once on site was to use sonar buoy-based video footage collected by the University of Washington as part of a separate study of the device. These drifts consisted of multiple drifts that started upstream of the device and ended downstream, with a surface-mounted video camera pointed vertically towards the streambed. This footage was collected independently of and concurrent to the fish monitoring study, and provided postseason by the University of Washington (Dr. Brian Polagye).

At the BRI device, Camera 2 had a view of the substrate for the first 3-5 m downstream of the device.

Wildlife monitoring

Visual surveys for wildlife were conducted from shore each day the devices were operational. At each device, an observation site was chosen nearby based on proximity to the device, the field of view, and access. The surrounding riverbanks, islands, and stretches of water were divided into zones delineated by natural landmarks, and enabled the technicians to place animal sightings into specific areas that were consistent through the season.

Each wildlife survey was for 10 minutes. During the survey, the technician continuously scanned the zones both by eye and with the aid of Fujinon 7x50 binoculars. At the beginning of each survey, the observer noted the following: time, date, presence and operational status of the RISEC device, percent cloud cover, wind speed, rain, any potential visual impediments (e.g. glare, smoke, fog), and any other operations being conducted (e.g., sonar surveys, maintenance of RISEC device). Each 10-minute survey was preceded by a 5-minute “calming” period to offset any unintentional disturbance of wildlife by the observers as they arrived; this 5-minute period was not an official part of the survey.

For each bird and mammal sighting, the following were recorded:

- Species, or group if the species was not apparent.
- Count (noting juveniles, if present)
- Sighting cue (audio or visual)
- Location area / zone
- Habitat type (Air, Water, Vegetation, Ground)
- Movement relative to device (Towards, Away, Neutral)
- Reactions to device presence (e.g., looking at the device, changing course, splits in groups, changes in behavior)
- Interactions with the device (e.g., landing on the device itself, circling the device either on the water or in the air)
- Comments

Each sighting was also categorized by whether the animals arrived at the survey area, left the survey area, transited through the survey area, or remained in the survey area throughout the survey.

RESULTS

Camera, lights, and recording equipment were tested prior to deployment (Photo 5). Once deployed, the equipment functioned reliably, with no breakdowns of camera gear or lighting. Inseason progress reports were delivered on July 10 and August 5, and a season summary was delivered September 30 (Appendix B). Final effort and results are summarized by device, below.

ORPC device

Operations

The ORPC device was deployed on the river bottom on August 13, 2014 at approximately 1600, with the turbine starting to operate (spin) shortly thereafter. The turbine operated intermittently until September 10; the device was removed from the river on September 13. Camera operations matched the turbine schedule, operating intermittently from August 13 at 17:43 through September 10 at 15:00.

The five cameras and two lights all operated as planned. Video was recorded during all 87 hourly blocks when the turbine was operating. Lights were operated during most hours of nights when the device was operating.

Visibility was consistent across cameras: reviewers could see an estimated 10–15 ft from each camera, based on background markings, with good resolution. Water was more turbid after rain events, and turbidity increases noticeable to the human eye at the water surface were also noticeable on imagery from the cameras at the river bottom. The downstream view on Camera 5 was most difficult to review for fish because there was little contrast in the background view; the other four cameras had partial views of the device structure, which provided contrast that helped discern fish during video review.

Imagery collection and review effort

The device was operated intermittently on all or parts of 17 days from August 14 through September 10. We separated the 696 potential hours during this time into the following four categories (Table 2):

1. Group A: 87 hours while the device was submerged and operating. We recorded all 87 of these hours, then reviewed the 83 (95%) for which water visibility was acceptable. Across all five cameras combined, this totaled 415 hours of coverage.
2. Group B: 471 hours while the device was submerged but not operating. We recorded 117 of these hours, then reviewed 28 of them (24%), which totaled 140 hours combined among all five cameras.
3. Group C: 55 hours while the device was on the surface and not operating. We recorded none of these hours.
4. Group D: 83 miscellaneous hours while the device was submerged and either operating briefly or not at all. We recorded and archived all 83 of these hours, and reviewed none.

In total, 10-minute subsamples were thus reviewed from 111 hourly blocks of data per camera, or 555 hours for all cameras combined (Table 2). Exactly 75% of these were while the device was submerged and operating. These represented 95% of the time the device operated.

Fish detections

Fish were detected on 32 separate events, representing 52 fish. Fish detection events were spread over 9 days; the most were on August 22, with 12 events representing 31 fish (pink salmon, chum salmon, and coho salmon; *O. gorbuscha, O. keta*, and *O. kisutch;* Table 3). The 52 fish detected consisted of 32 pink salmon, 2 chum salmon, 2 coho salmon, 14 fish of uncertain species, and 2 events that may not have even been fish. Uncertain species were usually juvenile-sized salmonids or adult-sized fish that were hard to distinguish between salmon and trout. 80% of sightings were at Camera 1.

After standardizing for effort, sightings translated to 0.09 fish per hourly block at the device (52 fish divided by 555 hourly blocks among all cameras combined; Table 2). Sightings peaked between 1600 and 1800, accounting for over half of the sighting rate (Figure 5).

Fish behavior

All behavior by live fish was milling, or traveling up- or downstream (Table 4). Milling was the most common behavior and was a mix of movements. A typical view was for the fish to drift down from above, or to emerge from the substrate along the pontoon. Many pink salmon showed this behavior. Dead fish drifted with the current and were easily differentiated from live fish.

Direct, sustained movement upstream or downstream was less frequent than milling behavior. A group of four pink salmon moved upstream (Camera 1) on Aug 22. These fish were not detected on the other cameras. Four fish, all of which were pink salmon, were detected moving downstream. All of these were seen upstream of the turbine; two were dead or torpid, one was unknown, and one was a pink salmon that appeared to move downstream and over the device.

Several fish were seen on Cameras 4 and 5, downstream of the turbine; these were all three of the coho or potential coho salmon seen, and all were classified as milling.

There were no detections of fish contact with the turbine itself and no evidence of passage delay (while the device was operational or not). A few fish appeared to use the pontoon eddy as a velocity shelter, but not the turbine structure. Qualitatively, there was no evidence of device status (turbine spinning vs. stationary) or diel timing (day vs. night) on fish presence; sample sizes were too small to compare quantitatively.

BRI device

Operations

The BRI CycloTurbine was installed on August 29, 2014 at 21:30. The turbine operated from this time until August 31 at 20:30. Cameras operated from August 30 at 0900 through September 2 at 10:25, thereby recording images both while the turbine operated and after it had stopped. The device stopped before a light could be installed; therefore, no imagery was collected at night.

The downstream view from Camera 1 was better at night (with the light) than during the day. The reflection of the aluminum, sometimes coupled with direct sunlight, reduced image quality at times. Camera 2 was better for viewing because it had less reflective glare and because it viewed fish in cross section (i.e., looking laterally across river).

Imagery collection and review effort

The device was operated intermittently on all or parts of four days from August 29–September 5. The 86 potential hours during this time were separated into the following two categories (Table 2):

1. Group A: 47 hours while the device was submerged and operating. We recorded 34 of these hours, and reviewed 10-minute subsamples from all of them. Across both cameras, this totaled 68 hourly blocks reviewed.
2. Group B: 39 hours while the device was submerged but not operating. We recorded all 39 of these hours and reviewed none of them.

In total, 10-minute subsamples were thus reviewed from 34 hourly blocks of data per camera (from 68 hourly blocks total), all of which were while the device was submerged and operating. These represented 72% (34 of 47) of the time the device operated (Table 2).

Fish Detections

Fish were detected fish during 48 separate events, totaling 53 fish. These sightings were 19 pink salmon, two chum salmon, five sockeye salmon, two lamprey, and 25 unspeciated salmonids (likely whitefish or trout; Table 3). All but four of the fish detected were at Camera 2 (the downstream camera).

Fish at the BRI site were spread more evenly throughout the day than at the ORPC site. Despite the relatively short deployment time, fish were seen every hour from 0700–2000. After standardizing for effort, sightings translated to 0.78 fish per hour of review time at the device (53 fish seen over 68 hours; Table 2); no single hour accounted for more than 15% of this sighting rate (Figure 5).

Fish Behavior

All fish detected on Camera 2 were milling (30 fish) or moving upstream (18 fish; Table 4). A typical milling behavior was fish appearing downstream of the device and holding downstream of the device, before moving sideways and/or downstream. The fish were usually an unidentified species of salmonid. A typical upstream behavior was for fish to approach the device, hold briefly, and then move upstream and around or to swim under the downstream edge of the device. We saw no adverse effects on these fish, most of which were pink salmon.

The four fish seen on Camera 1 were all traveling downstream. Four pink salmon migrated around the BRI device, one lamprey migrated above it, and one lamprey moved downstream through the device. This fish entered the device from the top, on the downstream portion of the debris guard; either the guard had broken here, or the sinuous body shape of the lamprey allowed it to pass through the guard's barrier cables. This fish presumably moved through the device and could have had contact with the turbine. Further effects on the fish could not be evaluated because the event was at night (0500 hrs), before a light had been installed on the downstream end of the device.

Visual verification of camera results, and indications of scour

The buoy-based video footage from University of Washington came from camera drifts over the ORPC device multiple times from August 21 through August 24. Each drift lasted approximately three to five minutes. Imagery was reviewed footage from all drifts; no fish were seen within the field of view of our fixed underwater cameras, either because no fish were there during drifts, or because it was at the limit of the drifted camera's range. The drifted camera was able to see fish elsewhere (water depth approximately 6–8 feet), and was able to see the turbine and some substrate at the device (approximately 20 feet deep); without further assessment of this camera, however, it can't be known whether the absence of fish was a true negative. This footage also showed no indication of gravel disturbance or other forms of scour downstream of the device.

At the BRI device, Camera 2 had an effective view of the substrate for 3 –5 m downstream of the device and showed no signs of scour. The short operation time (Aug 29 – Aug 31) prevented using any secondary methods to view fish.

Wildlife monitoring – both devices

A total of 28 wildlife surveys were conducted from August 15 through September 10; of these, 25 were at the ORPC site and 3 were at the BRI site. No animals came into physical contact with, interacted with, or otherwise reacted to either device. No animals exhibited changes in behavior or course of travel while in close proximity (within 30 m) of a device.

There were a total of 68 sightings of 151 individual animals. The sole mammal sighting was of a red squirrel (*Tamiasciurus hudsonicus*). All other sightings were of birds, the majority of which were gulls (Table 5).

Most bird sightings consisted of individuals or groups flying over the river corridor; the remaining were birds that landed in view during the survey, or that were already in view at the time of the survey (Table 6).

DISCUSSION

Presence of fish and wildlife near the devices

There was no evidence of effects on fish and wildlife at the ORPC device during the deployment period of August 13 to September 10. Notably, there were no sightings of birds swimming or diving at the device; only three groups were seen within viewing distance during the 25 surveys at this site. Fish encountered the device at low levels through the period, mostly holding near the pontoons upstream of the turbine; no fish were seen entering the turbine, and only one appeared to pass over (an adult salmon, moving downstream). Although there was space for fish to migrate underneath the turbine, we did not see this. Most sightings were adult-sized salmonids. Smaller fish would have been harder to see but still detectable within five feet, so their relative scarcity in the camera views was at least somewhat representative.

There was also no evidence of effects on wildlife at the BRI device, but observed higher rates (fish/hr) than at the ORPC site (with the caveat of a shorter sampling period). The most notable fish behavior was migration of pink salmon upstream and around the device; these fish thus showed some avoidance behavior, but the device did not appear to hinder fish passage and fish did not move upstream into the device. Fish also appeared to use the device as a velocity shelter, holding and milling slightly downstream of the device. The two pink salmon seen moving downstream both went around the device, perhaps due to the fish guard. One lamprey went through both the guard and the device; unfortunately, a light had not yet been installed downstream and the status of this fish could not be assessed when it exited the device.

The placement of the both devices ~ 100 m from shore may have helped reduce salmon presence by putting them outside of the main migration corridor of salmon. Differences in physical conditions between the study sites may have also helped contribute to differences in fish presence between the devices. Anecdotal evidence from ADF&G (R. Regnart, personal communication), supported by field observations during this project, is that most sockeye salmon migrate within 30 feet of each river bank, and approximately 60–70% of the run migrates up the left bank. Assuming this is also representative of pink salmon (weaker swimmers than sockeye salmon), both devices may have been out of the main migration corridor of the two most abundant salmon species. Although the peak of the run had passed, many salmon were still being seen along the shoreline through August by project biologists, in densities that were (qualitatively) higher than seen on the cameras at the devices.

The ORPC site was also high energy relative to the rest of the river cross section, which had eddies and much slower water velocities near each bank. These environmental conditions meant that fish had easier migration corridors further away from the device, and may have helped further reduce fish presence at the device. Although the design of the ORPC device would have also allowed fish to pass unobstructed below the turbine, no fish were seen doing so.

Wildlife sightings consisted almost entirely of birds, none of which showed a behavioral response (attraction or avoidance) to the device.

Equipment operation

There was a demonstration component to the fish monitoring portion of this project, given that it was the first such design used to monitor these types of devices in Alaska. The equipment operated effectively, with no breakdowns of gear once it passed shoreside testing. The specifications of the two main pieces of equipment worked well together, in that the lights were able to illuminate an area exceeding the cameras' effective views. Placement of lights behind the cameras worked well, with no glare problems. There were no apparent problems from vibration, such as from water current or mounting structures. One drawback to the video is that because it was designed for motion imagery, still images captured from the video are unrepresentatively poor and thus not reproduced here. Video samples are archived by the project (Appendix A) and available for distribution with this report.

Water turbidity and image background influenced the ability to interpret images. The effective range (distance) also changed depending on the question asked – cameras generally needed to be within 6 feet to identify juvenile salmon or speciate adult salmonids, within 10 feet to speciate adult salmon, and within 15 feet to characterize fish behavior and distinguish adult fish from debris. These distances allowed us to effectively address whether fish were entering the entire BRI device or the nearest 1/3 of the ORPC turbine, for example, but would have been less effective for differentiating behavior among trout species. Fish were more distinguishable against backgrounds with contrast (such as the ORPC turbine in the background) than without (such as with only the riverbed in the background).

Although the underwater imagery at the ORPC site was partial, it is likely representative for several reasons. Temporally, the subsampling approach (a ten-minute count each hour) is common for salmon in Alaska in general and on the Kvichak in particular (Anderson 2000; Reynolds et al. 2007), and should be sufficiently representative over time. Spatially, the one-third of the device visible in the cameras seems reasonably representative of the rest of it, given the uniform design of the device and the consistency of the water conditions at that site. Finally, the imagery was collected on 17 days spread across a 28-day time period, increasing the likelihood that a major change in run behavior or distribution would have been seen. The two cameras at the BRI device were able to capture 95 – 100% of the entry and exit.

Visual verifications with a secondary method were originally intended to ground-truth the primary cameras, and meant to be developed on site once characteristics were known. The backup method chosen (camera drifted over the device as part of a separate study) was the best available option, but the need for it became reduced when the primary cameras proved to function effectively and see fish clearly. This secondary validation method should be retained in the future in case any questions develop with the main camera system. Verification surveys at the BRI device were not possible due to the short deployment time.

CONCLUSION AND RECOMMENDATIONS

Fish seen during the study period did not seem negatively impacted by the devices, either because of the design or the placement location (or both). When present, upstream-moving salmon were able to migrate around the devices. Downstream fish appeared able to migrate around the ORPC device on their own, and the fish guard on the BRI device appeared effective for salmonids, although perhaps less so for lamprey.

The study identified a number of monitoring features to retain or adapt for future work, depending on objectives. The underwater video effectively monitored fish behavior around hydrokinetic devices on the Kvichak River, and worked for nighttime operation when paired with lights. Improvements may be needed to scale the effort up to larger sampling intervals, analyze more imagery, or refine fish identification. Depending on future objectives, some potential improvements are as follows:

1. Retain the fixed mounting system eventually selected for both cameras and lights in 2014.
2. Replace battery banks with 110 v power.
3. Describe fish during times of higher inriver fish abundance to determine if the distribution and behavior at the devices in 2014 was representative.

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Project planning was a key part of this initial effort. Bill Price (Gray Stassel Engineering) led the overall permitting effort and provided important guidance to the monitoring plan and study. Alan Baldevieso and Alan Fetters (Alaska Energy Authority) provided administrative help, along with logistical boosts at key times. Jim and Judy Boschma helped with study pre-planning and administration. Guy Wade helped develop the initial monitoring plan, which was further improved by reviews by ADF&G.

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TABLES

Table 1. List of fish species known or suspected to use the Kvichak River near site of this study. Subsistence use is from Krieg et al. (2003).

Common name[a]	Scientific name	Subsistence use	Habitat use at study site[b]	Seasonal timing
Alaskan brook lamprey	*Lampetra alaskense*	No	Migrant	unknown
Arctic-Alaskan lamprey	*L. camtschatica/alaskense*	No	Migrant	unknown
longnose sucker	*Catostomus catostomus*	Yes	Migrant	Spring
northern pike	*Esox lucius*	Yes	Migrant/Resident	Spring/Fall
Alaska blackfish	*Dallia pectoralis*	Yes	non-typical	year-round
rainbow smelt	*Osmerus mordax*	Yes	Migrant	Spring/Fall
broad whitefish	*Coregonus nasus*	Yes	non-typical	Fall
humpback whitefish	*Coregonus pidschian*	Yes	Migrant	Fall
least cisco	*Coregonus sardinella*	Yes	Migrant	Fall
pygmy whitefish	*Prosopium coulteri*	Yes	Migrant	unknown
round whitefish	*Prosopium cylindraceum*	Yes	Migrant	unknown
Arctic grayling	*Thymallus arcticus*	Yes	Migrant/Resident	Spring/Summer/Fall
pink salmon	*Oncorhynchus gorbuscha*	Yes	Migrant	Summer
chum salmon	*Oncorhynchus keta*	Yes	Migrant	Summer
coho salmon	*Oncorhynchus kisutch*	Yes	Migrant	Summer/Fall
rainbow trout	*Oncorhynchus mykiss*	Yes	Migrant/Seasonal	Spring/Fall
sockeye salmon	*Oncorhynchus nerka*	Yes	Migrant	Spring/Summer
Chinook salmon	*Oncorhynchus tshawytscha*	Yes	Migrant	Summer
Arctic char	*Salvelinus alpinus*	Yes	Migrant/Seasonal	unknown
Dolly Varden	*Salvelinus malma*	Yes	Migrant/Seasonal	Spring/Fall
lake trout	*Salvelinus namaycush*	Yes	non-typical	year-round
burbot	*Lota lota*	Yes	non-typical	year-round
threespine stickleback	*Gasterosteus aculeatus*	No	Resident	year-round
ninespine stickleback	*Pungitius pungitius*	No	Resident	year-round
slimy sculpin	*Cottus cognatus*	No	Resident	year-round

[a] Alt et al. 1994 a,b; Fall et al. 2010; Gryska 2007; Groot et al. 1991; Hauser 2007; Hubartt 1994; Krieg et al. 2003; Mansfield 2004; Mecklenburg et al. 2002; Minard et al. 1992; Morrow 1980; Quinn 2005; Salomone et al. 2009; Woody et al. 2007

[b] Migrant - utilize study site seasonally as a migratory corridor
Seasonal - May reside in study site
non-typical - rarely encontered in study site
Resident - Majority of life cycle could occur in study site

Table 2. Image recording, review effort, and fish detections by device and operational status in 2014.

	Hourly blocks			Review hours[a]		Events		Fish	
Device Status	Hourly intervals	Hourly blocks with video recording	Hourly blocks with video review	Number of cameras	Total hourly blocks reviewed, all cameras combined	Fish detection events	Events / hourly review block	No. of fish	Fish / hourly review block
ORPC									
Floating on surface	55	0	0		0				
Submerged, not spinning	471	117	28	5	140	4	0.03	14	0.10
Submerged, spinning	87	87	83	5	415	28	0.07	38	0.09
Various/Intermittent	83	83	0		0			0	
Total	696	287	111	5	555	32	0.06	52	0.09
BRI									
Floating on surface	0	0	0		0				
Submerged, not spinning	39	39	0	2	0				
Submerged, spinning	47	34	34	2	68	48	0.71	53	0.78
Various/Intermittent	0	0	0		0				
Total	86	73	34	2	68	48	0.71	53	0.78

[a] Each hourly block reviewed consisted of a 10-minute subsample

Table 3. Fish species detected by device status and operational status in 2014.

Device	Device operating?	Hourly blocks reviewed[a]	No. of fish detected: Pink salmon	Chum salmon	Coho salmon	Sockeye salmon	Lamprey	Unidentified spp.	Total
ORPC	Yes	415	19	2	2	0		15	38
	No	140	13					1	14
BRI	Yes	68	19	2	0	5	2	25	53
	No	0							0

Table 4. Fish behavior by species for each device in 2014.

Behavior	Chum salmon	Coho salmon	Pink salmon	Unidentified	Sockeye salmon	Lamprey	Total	Comments
ORPC								
Drifting			2	2			4	2 dead/dying pinks; 1 unidentified; 1 juv
Milling	2	2	26	7			37	Variety of behaviors
Travel, down				4			4	All upstream of turbine; 1 fish might go over
Travel, up			4	2			6	All upstream of turbine
Undetermined				1			1	
Subtotal, ORPC	2	2	32	16	0	0	52	
BRI								
Milling	1		2	23	4		30	Variety of behaviors
Travel, down			2			2	4	2 pinks around; 2 lamprey go over, thru
Travel, up	1		15	1	1		18	15 went around/under
Undetermined				1			1	
Subtotal, BRI	2	0	19	25	5	2	53	
Grand Total	4	2	51	41	5	2	105	

Table 5. Total number of wildlife sightings (number of individuals) by taxonomic group seen during wildlife surveys at the hydrokinetic devices in 2014. Device status during each survey is described as Operating (submerged and rotating, n=16), Not Operating (submerged and not rotating, n=10), or At Surface (not submerged and not rotating, n=2).

	Device Status			
Taxonomic Group	Operating	Not Operating	At Surface	Total
Small Mammals	0	0	1 (1)	1 (1)
Waterfowl	0	4 (24)	0	4 (24)
Bald Eagle	2 (2)	0	0	2 (2)
Other Raptors	0	1 (1)	0	1 (1)
Shorebirds	1 (1)	1 (7)	0	2 (8)
Gulls	30 (56)	1 (28)	4 (4)	35 (88)
Corvids	2 (2)	2 (2)	1 (1)	5 (5)
Passerines	12 (14)	3 (4)	3 (4)	18 (22)
Total Birds	47 (75)	12 (66)	8 (9)	67 (150)

Table 6. Movement behavior by number of sightings (number of individuals) for the wildlife in areas nearest (~ 200 m) the hydrokinetic devices in 2014. Movements categorized as Arrived (animal entered area during sighting), Departed (animal exited area during sighting), Remained (animal stayed within area throughout the duration of the sighting), Transited (animal entered and exited area during sighting), and Unknown (unable to determine, applies to animals detected by audio cue). Data excludes the 5-minute calming period before each survey.

	Movement of Animals in Areas Nearest Device					
Taxonomic Group	Arrived	Departed	Remained	Transited	Unknown	Total
Small Mammals	0	0	0	0	1 (1)	1 (1)
Waterfowl	0	0	0	1 (5)	0	1 (5)
Bald Eagle	0	0	0	0	0	0
Other Raptors	1 (1)	0	0	0	0	1 (1)
Shorebirds	0	0	0	2 (8)	0	2 (8)
Gulls	1 (2)	0	0	17 (40)	0	18 (42)
Corvids	1 (1)	0	0	1 (1)	1 (1)	3 (3)
Passerines	0	3 (3)	4 (6)	1 (1)	2 (2)	10 (12)
Total Birds	3 (4)	3 (3)	4 (6)	22 (55)	3 (3)	36 (72)

Areas not recorded for surveys 1-4

FIGURES

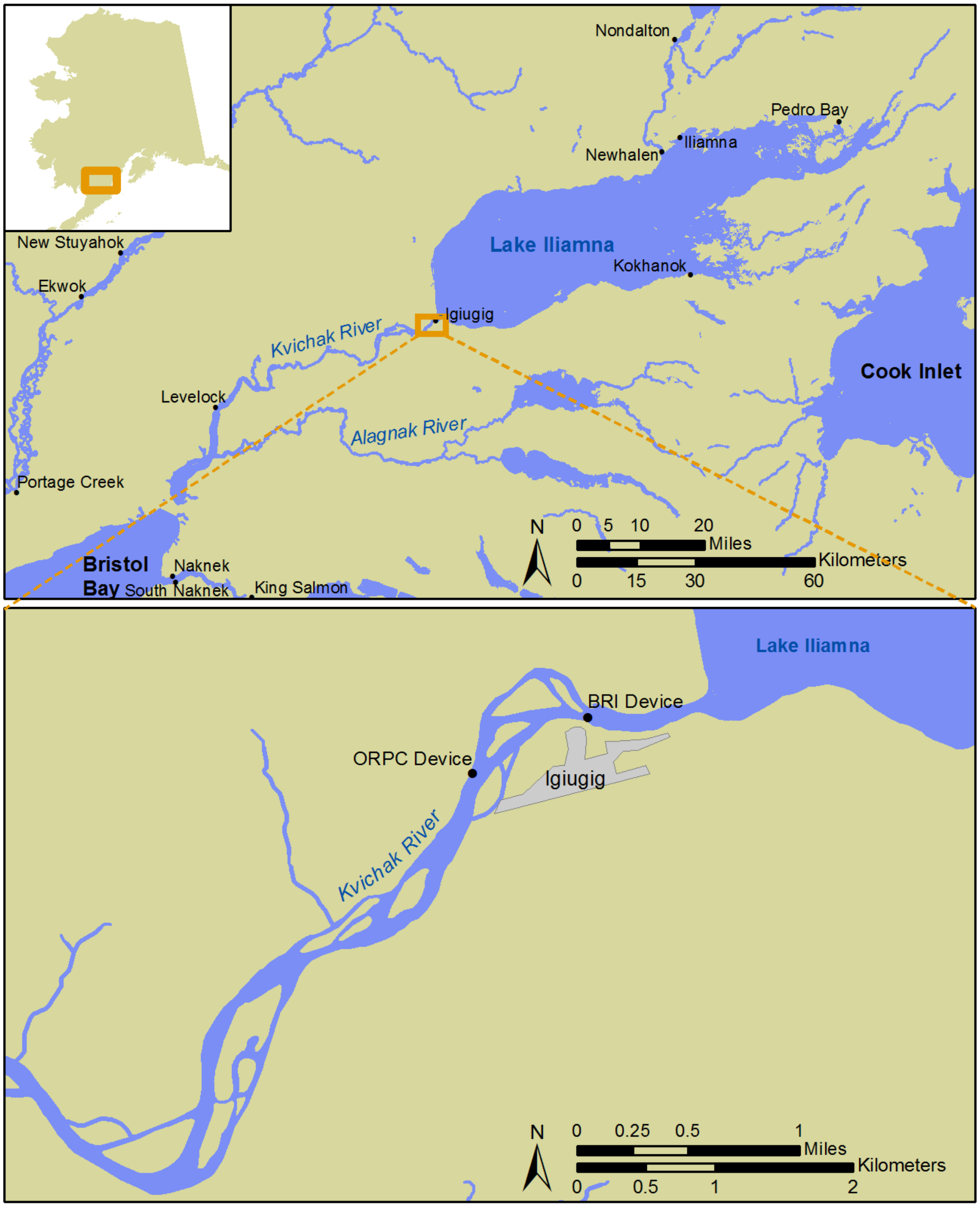

Figure 1. Map of the Kvichak River in southwestern Alaska, showing locations of the hydrokinetic devices built by ORPC and BRI and operated near the village of Igiugig in 2014.

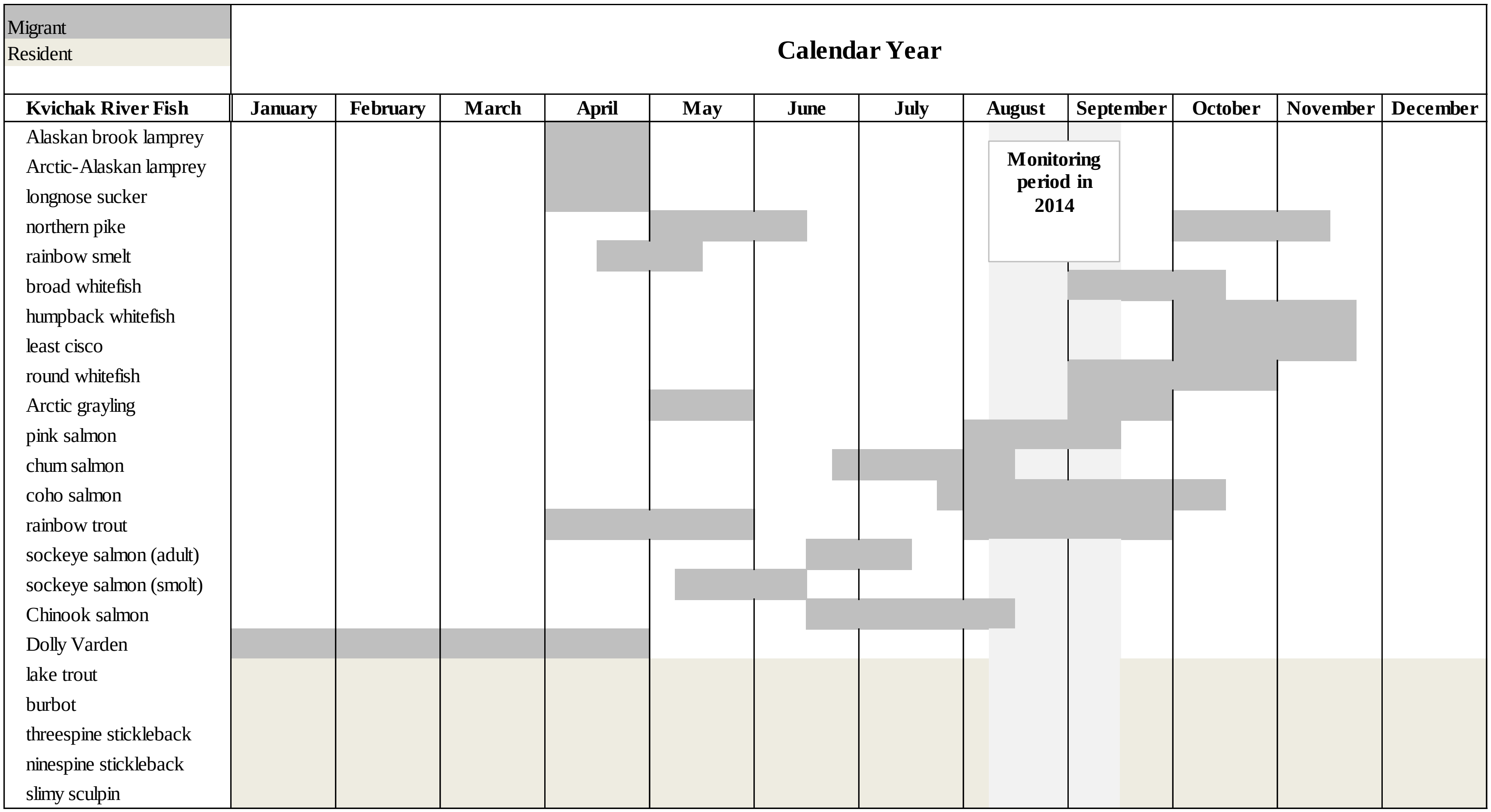

Figure 2. Approximate temporal peaks in fish presence, by species, in the Kvichak River near Igiugig relative to the 2014 monitoring period of August 13 – September 10 (multiple sources; see Table 1).

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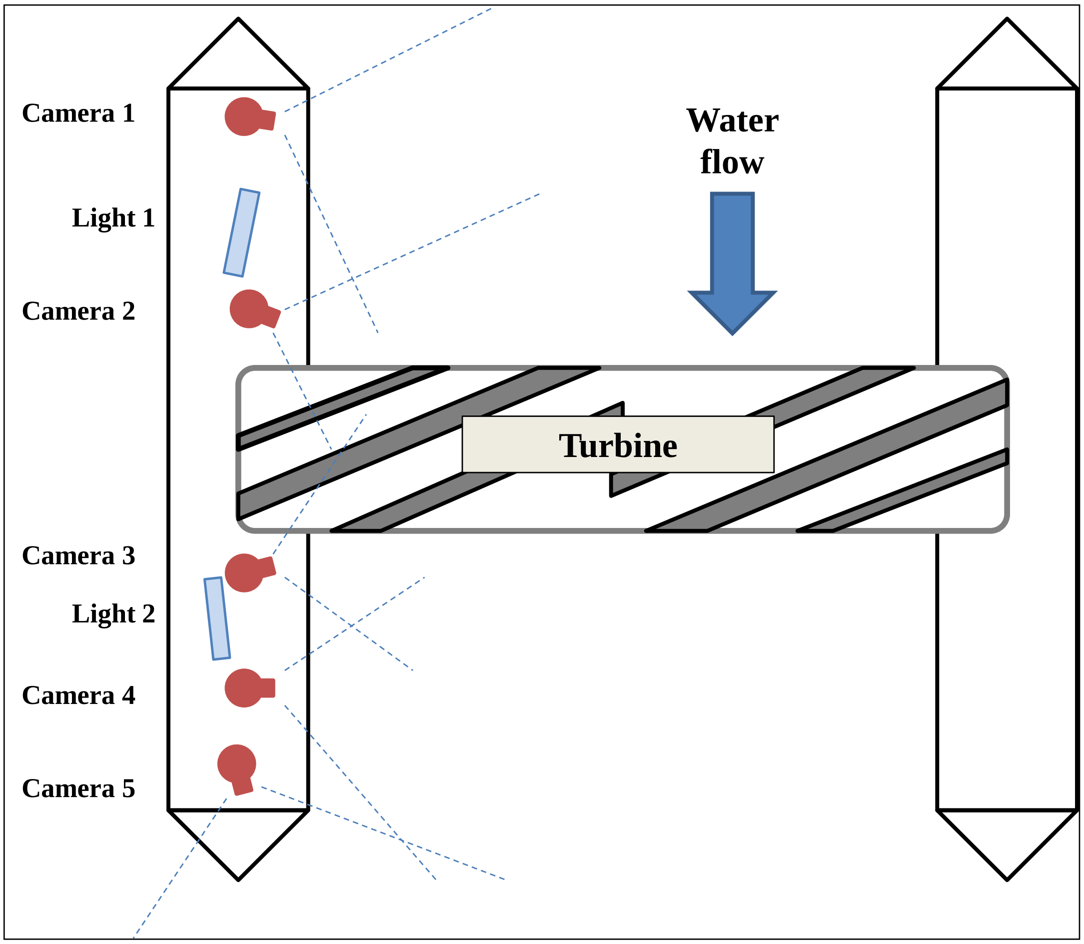


Figure 3. Schematic of ORPC device once submerged, showing final location of cameras and lights along the port side pontoon of the device. Dashed lines model the field of view from each camera. Schematic is not to scale.

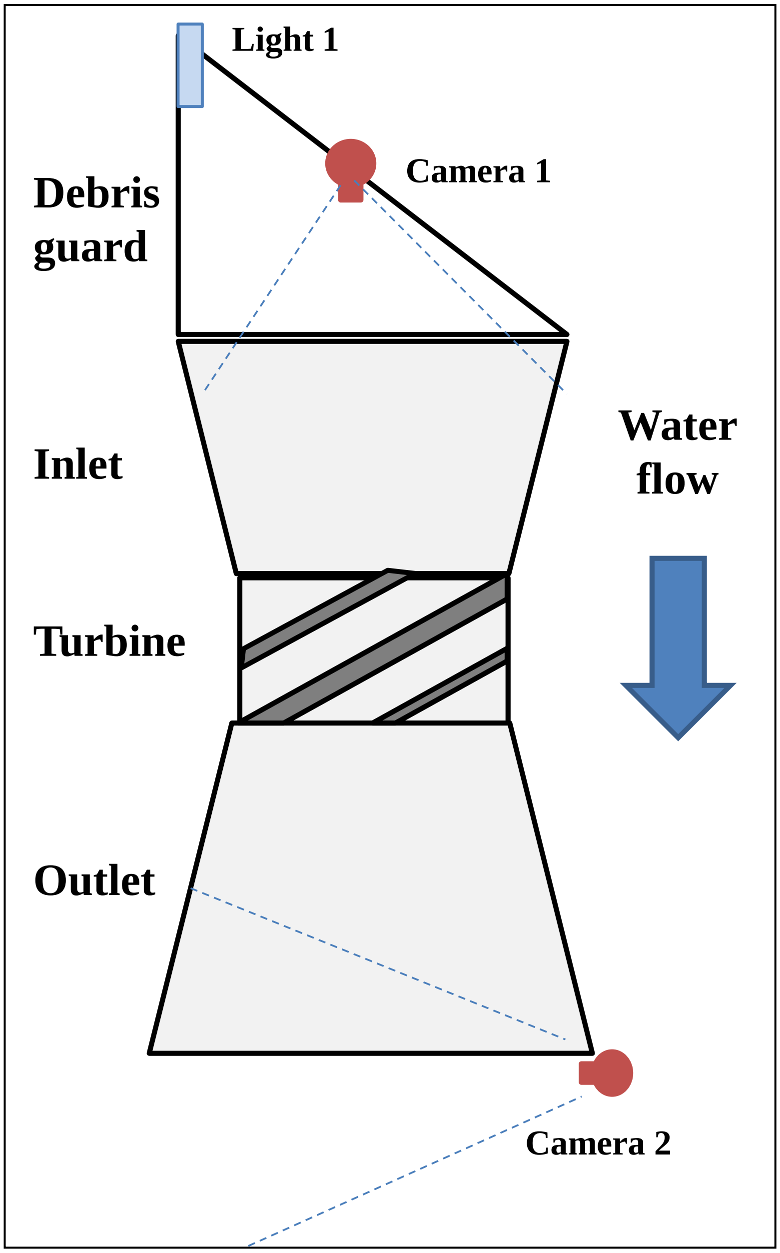


Figure 4. Schematic of BRI device once submerged, showing final location of cameras and lights. Dashed lines model the field of view from each camera. Schematic is not to scale.

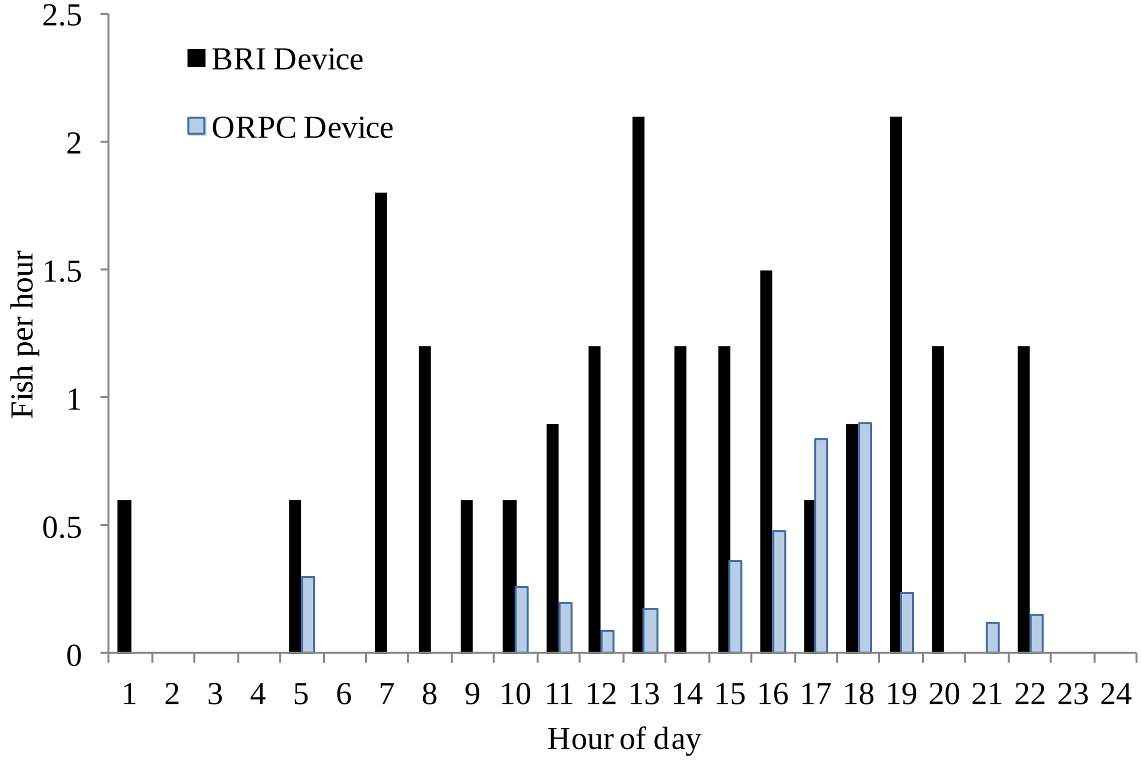


Figure 5. Fish detections by hour of the day at each RISEC device, standardized for review effort.

PHOTOS

Photo 1. ORPC device before deployment, showing approximate mount locations of underwater cameras (C1 – C5) and lights (L1 – L2) in 2014. Water would flow from left to right.

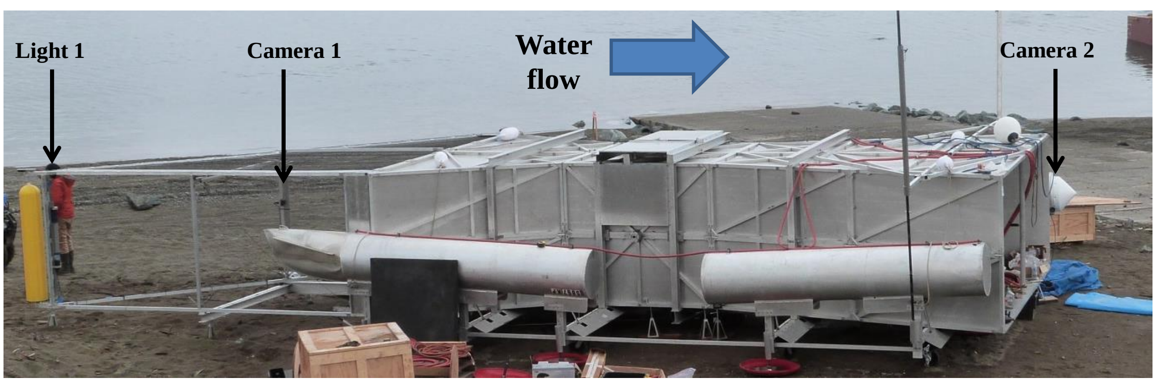


Photo 2. BRI device before deployment, showing mount locations of underwater cameras and light used during deployment in 2014. Water would flow from left to right.

Photo 3. Surface view of the BRI device while submerged on September 1, 2014. Water flowing from right to left; device is the white object visible in right center of photo.

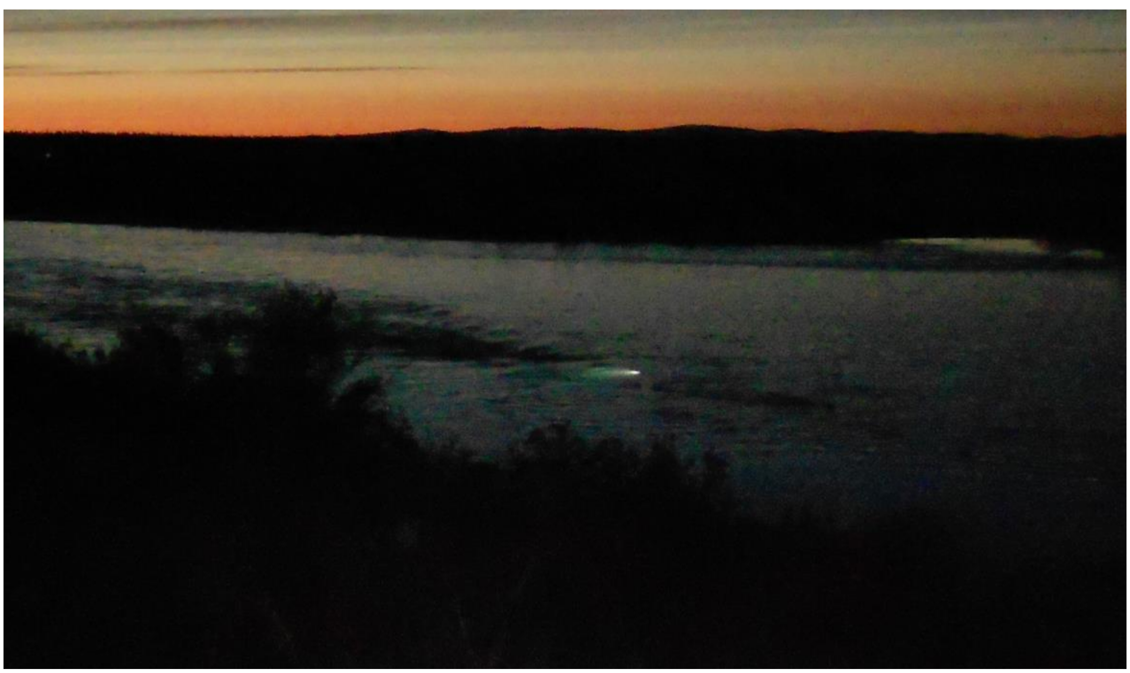


Photo 4. Surface view of the BRI device at night while submerged on August 30, 2014 at 11:00 pm. Illumination from underwater light attached to device is visible in right center of photo. Water flowing from right to left.

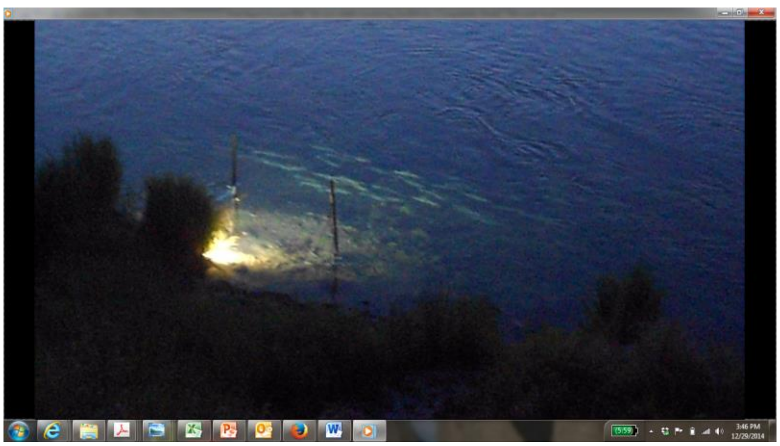
Photo 5. Surface view of pre-deployment testing of the underwater lights at 1:00 AM on July 3, 2014. Approximately ten sockeye salmon are seen migrating within the illumination field, at the top center of photo. Image is from a conventional (not underwater) camera, from about 20 m away.

Photo 6. Shoreside cabinetry that housed the video recording system and power link for the BRI RISEC device in 2014. Marker buoys for the submerged device can be seen at top left of photo.

APPENDIX A – SAMPLE VIDEO IMAGERY

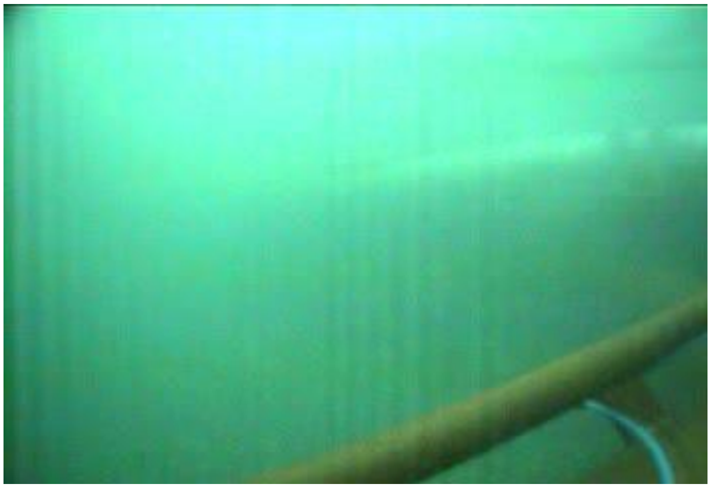
Video clips available for distribution upon request.

A1. Sockeye salmon migrating past test site during pre-deployment testing of underwater lights, 7/3/2014. Video taken from above the water surface using a conventional camera.

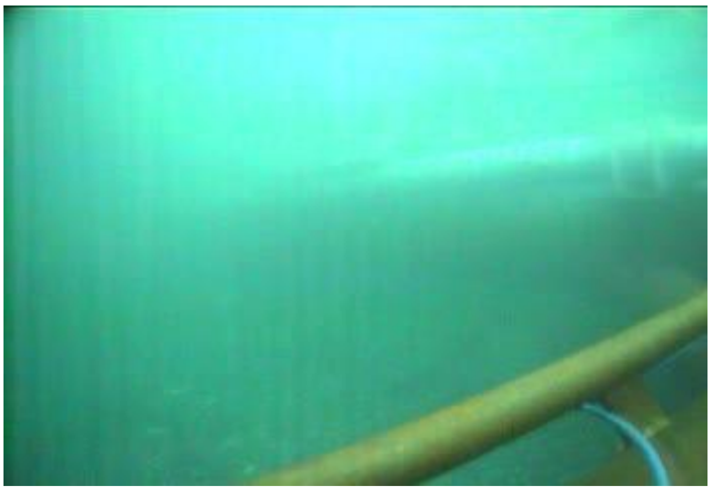


A2. Coho salmon video clip from the ORPC device, 8/21/2014.

A3. Chum salmon video clip from the ORPC device, 8/25/2014.



A4. Pink salmon video clip from the ORPC device 8/21/2014.



APPENDIX B –2014 PROGRESS REPORTS

Progress reports filed during the monitoring study in 2014.

B1 – Inseason Update #1, July 10th 2014

B2 – Inseason Update #2, August 5th 2014

B3 – Season Summary, September 30**th** 2014

Fish and Wildlife Monitoring of Kvichak RISEC devices

In-season Progress Report #2014 - 1

TO: Bill Price, Gray Stassel Engineering, Inc.	**DATE: 7/10/14**
RE: Fish & Wildlife Monitoring	**REPORTING PERIOD: Through July 3**
Prepared by: Matt Nemeth, LGL Alaska Research Associates, Inc. **cc: Priest, Patterson, Funk, Cr. Ziolkowski (LGL)**	

This report summarizes progress through July 3rd by LGL Alaska Research Associates, Inc. (LGL) for fish and wildlife monitoring of the RISEC devices on the Kvichak River. July 3rd marked the end of the first field trip.

Overall status

Neither RISEC device has been deployed, so LGL's work to date has consisted of preparation and designs. The BRI device has been outfitted with two specialized underwater cameras and one light, fastened directly to the device on "fixed mounts." Once the device is ready for deployment, we will need approximately one day to make the electronics operational. The ORPC device has been outfitted with fixed mounts for six cameras and two lights. Two to three days will be needed to install the electronics on these mounts, route the cables, assemble the shoreside power bank, and deploy the cables from the device to the power bank. These steps must be coordinated with other work on the device (non-LGL), and won't be started until the device deployment schedule(s) are firmed up.

Summary of field efforts through July 3

Preparation

Most work in June was spent preparing for our (LGL's) June 25 departure to Igiugig. Materials needed for mounts were generally shipped unassembled, partly for logistical reasons and partly to help accelerate the potential deployment schedule. Overall, this appeared to have been the correct approach. Assembling in Igiugig helped get bulk items such as cement and steel sent earlier and more cost effectively, and gave us greater flexibility once on site and able to assess the devices in coordination with BRI and ORPC staff. The last shipment of cameras and lights was received June 27th.

Camera and light designs

Upon arrival in Igiugig, we prioritized work on the BRI device to support a potential deployment as soon as June 28. One camera (BRI-1) was attached halfway along the debris guard that forms the bow (upstream end) of the device. This camera faced downstream, positioned to view fish moving towards the device mouth from approximately 20 feet upstream (Figure 1). A second camera (BRI-2) was attached to the stern (downstream end) of the device at its exit. This camera faced sideways but slightly downstream, positioned to capture fish downstream of the device (moving either upstream or downstream). One light was fixed approximately 10 feet upstream of camera BRI-1 (Figure 1), and a second will be added using mobile mounts, near camera BRI-2. One to two additional cameras will be added using mobile mounts (i.e., not attached to the device); these will be added after the device's deployment, in a way that best completes the intended fields of view described in the monitoring plan.

The ORPC designs were finalized such that mounts for six cameras and two lights were attached along the port side pontoon, split evenly upstream and downstream of the turbine that spans the pontoon centreline. This arrangement seem superior to the prior, tentative plan of having only up to three cameras mounted on the pontoon. The six camera mounts (ORPC 1-6) are positioned to collectively show an approximate 180-degree field of view from the bow of the device (ORPC-1, looking sideways) to the stern of the device (ORPC-6, looking directly downstream), and should provide most of intended fields of view described in the monitoring plan. Fish moving between the bow and stern can be captured synoptically by the different cameras; the fields of view may overlap or have blind spots, depending on distance from camera.

One challenge with the ORPC device is that we can't know camera performance *in situ* until the device is sunk, after which it can't be re-floated just to adjust cameras. Therefore, we may remove one camera (ORPC-2) beforehand and reserve it for a mobile placement after seeing how the fixed cameras perform. This camera would be used to complete the intended field of view in described in the monitoring plan.

Field testing

Fourth lights, nine cameras, and both DVRs tested correctly in Igiugig. The tenth camera works only in low light. A number of smaller glitches have been, or are still being, troubleshot. The full system was used successfully to identify sockeye salmon swimming near the BRI site, day and night, from a distance of 10 to 15 ft from the camera, in water 2 to 3 ft deep.

Future field work

Both device makers are revising their deployment schedules the week of July 7, with little work we can do on site in the interim without exposing the gear to surface damage while not being watched. We've therefore removed our staff from Igiugig for the time being.

Once the BRI device is floated onto its anchor and pulled to shore, we will inspect the electronics attached in June, deploy our cables between the shore and deployment site, and install shoreside electronics and temporary power lines at the optimal site between the device and the BRI power source. This will allow us to begin monitoring using the two fixed cameras. The two mobile cameras will then be phased in, where needed. Our cabling will be independent of BRI's.

Once the ORPC schedule is determined and further float tests are complete, we will attach the cameras and lights. The device will then be floated onto its anchor and all cabling (ORPC and

LGL) will be run to shore. We will then install the shoreside power supply and electronics and begin monitoring. Our cabling will be independent of ORPC's.

July work will be summarized in the next progress report on August 4th.

Table 1. Overview of location, view direction, and testing status of lights and cameras as of July 3. Some camera locations may be further rearranged.

Gear	Code	Location	Direction of view	Tested
Camera	BRI-1	Starboard bow, midway up debris guard	Down	OK
Camera	BRI-2	Starboard stern, at device exit	Across and down	OK
Camera	BRI-3	Mobile	TBD	OK
Camera	TBD	Mobile	TBD	Problems
Light	BRI	Center, bow, upstream end	Downstream	OK
Light	BRI	Mobile	TBD	OK
Camera	ORPC-1	Port side, bow, upstream	Across	OK
Camera	ORPC-2	Port side, bow, midway	Across	OK
Camera	ORPC-3	Port side, bow, near turbine	Across and down	OK
Camera	ORPC-4	Port side, stern, near turbine	Across and up	OK
Camera	ORPC-5	Port side, stern, midway	Across	OK
Camera	ORPC-6	Port side, stern, downstream	Downstream	OK
Light	ORPC	Port side, bow, midway	Across and down	OK
Light	ORPC	Port side, stern, midway	Across and up	OK

Figure 1. Location of mounts for two cameras (white arrows) and one light (red oval) on the BRI device. Water would flow from left to right.

Figure 2. Location of mounts for six cameras (white arrows) and two lights (red ovals) on the ORPC device. Water would flow from left to right.

Fish and Wildlife Monitoring of Kvichak RISEC devices

Inseason Progress Report #2014 - 2

TO: Bill Price, GSE	**DATE: 8/5/14**
RE: Fish & Wildlife Monitoring	**REPORTING PERIOD: July 3 – Aug 3**
Prepared by: Matt Nemeth, LGL Alaska Research Associates, Inc. **CC: Priest, Patterson, Funk, Cr. Ziolkowski (LGL)**	

This report summarizes efforts by LGL Alaska Research Associates, Inc. (LGL) for fish and wildlife monitoring of the RISEC devices on the Kvichak River from July 3 through August 3.

Overall status

There is relatively little to report for this period. Deployment of both RISEC devices was delayed for various reasons unrelated to fish monitoring, and LGL's effort was primarily to remain prepared and sufficiently staffed during these delays. The ORPC device is presently at the barge landing in Igiugig and is outfitted with cameras and lights. The BRI device is presently downstream of the deployment site, with the damaged cameras and light removed. New ones will be installed just prior to the next deployment date. There are no substantial changes to camera designs or approach from last month.

The new plan is for deployment the week of August 4 (BRI) and August 11 (ORPC). As noted last month, we will need approximately one to two days to make the electronics operational once the devices are deployed. LGL will have 1-2 staff on site during deployment.

Summary of fish and wildlife monitoring of hydrokinetic devices on the Kvichak River in 2014

For update to FERC 9/30/14

From Matt Nemeth, LGL 9/26/14

All results are preliminary and subject to additional analysis

LGL Alaska Resources Associates, Inc. implemented the fish and wildlife monitoring plan in support of two hydrokinetic devices deployed on the Kvichak River in the summer of 2014. The overall goal was to monitor potential fish and wildlife interactions with the devices; implicit in this was testing the feasibility of using underwater video to detect, record, and quickly relay any undesirable interactions. The use of underwater cameras was made possible by the relatively clear water of the Kvichak River. Notable results include the following:

- Cameras were continuously operated for Device 1 (Boschma Research Inc.) on August 30 and 31, and for Device 2 (Ocean Renewable Power Corp) intermittently from August 14 through September 10 (operated during all hydrokinetic operations).
- The methodology was successful: cameras were able to be deployed near each device, were reliable for the duration of deployment, and effectively detected fish as far as 10 to 15 feet away. Images were able to be recorded shoreside and archived digitally. Underwater lights also allowed effective nighttime operation.
- No adverse fish or wildlife interactions were seen.
- Inseason, subsamples of underwater video were reviewed daily to continuously monitor fish interaction with the hydrokinetic devices.
- Inseason, wildlife surveys for mammals and birds were conducted on all days that the hydrokinetic devices operated. Combined with underwater video review, these surveys supported the inseason adaptive management plan guiding potential mitigation actions.
- The effectiveness of future video monitoring will be influenced by site characteristics (water depth and velocity, turbidity, substrate, distance from shore), the organisms to monitor, season, and the design of the devices. Other monitoring techniques could be used as needed.

Full results, conclusions, and recommendations will be included in a final report due December 15, 2014.