Champagne and Aishsihik First Nations Sockeye Salmon Video Enumeration Program 2005

Background

In response to concerns expressed by the Champagne and Aishihik First Nations (CAFN) that the counting weir operated on the Kluskhu River system was responsible for disrupting the natural migratory patterns of chinook and sockeye salmon on the system, CAFN undertook a project to determine the viability of using underwater video surveillance to inventory salmon.

An underwater surveillance prototype was developed in 2003 and consisted of a an I-Bot digital camera (Apple computer type), motion detection software (Security Spy© and a lap-top computer. The camera was placed in a modified Pelican case (water tight PVC container). The Pelican case was modified by placing a transparent plexiglass window in the cover, allowing the camera to record underwater. Using a standard 1 " bulk-head fitting a 1" pvc conduit was adapted to the case to allow for a water-proof connection via fire-wire to the camera from the lap-top.

It was determined that the prototype worked well enough to expand the trials over a protracted period during the 2004 field season. The 2004 program involved different equipment as described below. The gear used in 2004 was more practical and worked reasonable well. Therefore a program was designed to deploy a system in 2005 in-stream on Village Creek, a small sockeye salmon producing system located near the Klukshu River system in southwest Yukon. Village Creek receives upwards of 3,000 migrating sockeye salmon on an annual basis. Sockeye in the system are enumerated annually by The Department of Fisheries and Oceans (DFO) and CAFN through the use of a weir and an electronic counter. The accuracy of the counter has been brought into question over the years and therefore the video surveillance system could also be used to truth the counters numbers.

Underwater Video Salmon Surveillance Program 2004/2005

Equipment

Cameras

During the 2003 prototype trials a digital camera (ibod) enclosed in a modified waterproof case (pelican case) was used. A search for an "off the shelf" waterproof digital camera that was reasonably priced was not successful. Therefore the prototype system was modified to use an analog colour camera system and a digital convertor to transfer the signal to a laptop computer.

The cameras used during the 2004/05 were provided by Microvideo Products of Bobcaygeon, Ontario. The cameras are a "lipstick" type unit (approximately 5 cm long and 2.5 cm in diameter) enclosed in waterproof housing system and cable (see photo below). The cameras also come equipped with an LED lighting system that provides adequate lighting for up to 2.0 metres (depending on water clarity). Full swivel mounts were provided with the cameras but the mounts did not hold up well under constant adjusting required during the trials.

Only approximately 8 metres of cable were required on the cameras for this project as the lap-top computer and cameras were in close proximity to each other. Should the lap-top need to be located at a further distance it is possible to operate the cameras with up to 80 metres of cable. However, after 80 metres the image provided by the camera will begin to be compromised as the colour signals in the image travel at different speeds along the cable. At 80 metres or less the speed difference is not discernible but after an 80 metre run the colours will begin to separate and distort the image.

Underwater video camera with cable. Note LED lights around the camera lens

The cable is 100% watertight but the connection (bnc type) to the computer is not. Therefore care must be taken when setting up the system to avoid the connection from coming in contact with water.

Note: Although not tested during these trials it is possible to set up a remote camera system that does not require cables. This system comes with a radio type transmitter and receiver. The signal can travel up to 3 km without requiring a boast, however the transmitter and receiver must be in direct line with each other in order for it to work properly. This system was not tested during these trials so its reliability is unknown. They are also available through Micro Video Poducts of Bobcaygen, Ontario.

Digital Convertor

The cameras used during these trials were analog. Therefore in order to provide a signal that could be interpreted by the computers it was necessary to use an analog to digital convertor. The actual type of convertor used in these trials was an “ImagingSource” video to firewire Convertor (see photo below), model DFG/1394-1e. The convertor required 8-38 volts DC power. The convertor worked fine throughout the trials and did not slow the transfer of data to the computer in a significant way, nor did it appear to compromise the image in any noticeable way. The image from the camera was transferred directly to the digital convertor when only one camera was in use. When multiple cameras were used the camera signal was first past through a quad processor that converted the multiple signals into a single split screen signal that could be then digitised by the convertor. The signal from the convertor is then sent to the lap-top computer via firewire cable.

Analog to Digital Convertor with Fire wire cable (bottom of photo)

Quad Processor

As more then one camera was deployed during some of the trials it was necessary to link them together using a quad processor. The processor allows information from up to four cameras to be processed simultaneously. Thus, the image that would result on the computer screen consisted of one image divided into four quadrants (up to four, or in this situation –three camera views). The quad allowed for the option of treating each image individually or collectively. The type of quad processor used in these trials was an AVC 704 color quad processor (see photo below).

Using more then one camera allows for more accurate counting when several salmon pass by one of the cameras at the same time. The salmon closest to any given camera would block the image of a fish swimming adjacent.

One problem associated with the multiple camera system was that if the cameras were mounted on opposite sides of the migratory corridor the image being viewed was reversed on one of the cameras. For example, a fish captured in a camera left mounted in the corridor would be viewed swimming right to left on the computer screen whereas that same fish would be viewed by the right side mounted camera as swimming left to right. This took some “getting used to” when reviewing the data. However it is only necessary to view a single fish passing through on one of the screens unless one is looking for condition of the fish. However, when there is more then one fish swimming past the cameras simultaneously the multiple camera system make it possible to get a more accurate count.

Quad processor allowing up to four cameras to be used and record simultaneously

Computers

The video signal from the digital convertor was sent to an Apple iBook G4 lap-top computer. These computers contain a fast processor (1.07 GHz) capable of handling a video signal in real-time and it is also compatible with the security spy software deployed for these trials. The computers come with a 20 GB hard-drive.

The computers are quite small and portable and do not consume a lot of power. Power was conserved by dimming the screen to black during the trials. Two computers (same model) were purchased for the trials so that they could be exchanged easily so as not to interrupt the capture of data. While one computer is used to capture fish passage events the other computer could be transferred to an office for data analysis. The computers are equipped with CD burners that allow for the transfer and storage of data. The computer and peripheral equipment was housed in a plastic container in order to keep the equipment dry during the trials.


Ibook G4 laptop Computer used to store and playback video images

Software

The software deployed during these trails was Security Spy© which is set up to record video events based on motion detected.. The Security Spy© motion detection software allows adjustment for sensitivity and area of sensitivity. When a fish enters the field of sensitivity of the camera the motion-detection software is triggered resulting in the recording of that fish passage event. With respect to sensitivity, fish create a relatively high degree of motion relative to floating or suspended debris such as leaves. Adjusting the software to a low sensitivity reduced the number of events triggered by non-fish motion such as floating debris or water turbulence. The field of sensitivity was adjusted in order to reduce the number of false events recorded as a result of turbulence, floating debris and light reflection. Meanwhile the camera field of view still captured the water surface and bottom of the counting chamber to ensure all fish passing through could be captured.

The software allows for the adjustment of the length of video created once it is triggered to record. The recording event during these trials was set a seven seconds. Thus once motion is detected a seven second video is produced of that event. However, as long as there is still motion in the field of sensitivity the recording will continue past seven seconds.

The software also allows for recording what occurred just before a fish (or other object) triggers the recording of the event. This is accomplished by the software continually recording the camera images and storing them in a temporary memory file. When an actual event is triggered then the captured file can include what occurred in advance of the motion trigger. During these trials the software was set to capture two seconds in advance of the motion.

The event is stored on the hard-drive of the computer for future reference. Along with the video the date and time it was captured is also recorded.

There are many more features of this software that make it practical for this type of application. Details are provided in a manual (appended here) which is available online at: www.securityspy.com

Battery storage

Before implementing the system at the weir it was determined that the system cameras, laptops, invertor and digital convertor) would consume approximately 70-80 watts of power at 12 volts continuously. The Klukshu weir operates 24 hours a day and therefore has a 5 Kw power generator on site to provide nightime lighting and security for the employees. This generator thus was used to re-charge the batteries in the evenings during the 2004 trials.

Note: It is not recommended to use a generator of less then 5kw for charging deep cycle batteries.

"During a battery charging application power is only consumed from the very peak of the alternating current waveform" in Renewable Energy Handbook for Homeowners"

Two 12 volt deep-cycle batteries (175 Amp hours each) were used to provide power to the system. Battery power (DC) was converted to AC using a 400 watt invertor. Power was then transferred to the computer/camera system via AC cord. Using stepdown AC adapters power of the correct voltage was distributed to each of the components requiring power. These included:

Computer: 15 volts/3Amps
Cameras: 12 volts/ 150 mAmps
(the cameras can operate on 9 volts but with the LED lighting system 12 volts of power is required. If they lights are not required however 9 volts is suitable to operate the camera)
Analog to Digital Convertor 8-38 volts
Quad Processor 12 volts, 1 amp

Batteries used to provide power to computer, cameras and peripheral gear.

Power Invertor (400 watts). Converted 12 volt battery power to 110 volts.

Camera Trials 2004

The video surveillance program was conducted at a counting weir located on the Klukshu River approximately two kilometres upstream of the Tatshenshini River confluence in Yukon Territory Canada. Trials using the underwater surveillance system were conducted throughout the migratory period for the salmon at the weir. Salmon migrate up the Klukshu River from early June through October. Trials were not initiated until late June /early July

Cameras were placed at various locations within the confines of the counting weir. The weir consists of a fish passage barrier constructed of aluminium rods, aluminium and wood spacers and steel tripod type supports . The rods extend from the bottom of the river to above the surface angled downstream at approximately 45 degrees). One section of the weir, the gate, allows for the controlled passage of fish. A small shed is located over the gate to provide shelter for counting personal. This shed also provided shelter and protection for some of the video surveillance equipment.

Cameras were mounted at various locations within the fish passage gate in order to find the best location for the set-up. Locations were chosen in order to maximise coverage of the passage chamber yet avoid disturbances created by light, debris or turbulence in the water.

Weir passage chamber where cameras were mounted to record salmon migration. Note salmon heading upstream.

Each trial consisted of connecting the system and letting it capture images over a 24-48 hour period. These images were then viewed to determine the quality and quantity of images produced. Adjustments to the system were then made for subsequent trials based on the information collected each time.

For the most part the images of fish collected were clear and it was easy to distinguish species and in many cases gender. The main problem with the system was collecting unwanted images of debris floating past or due to other influences such as lighting, or turbulence. It was difficult to set the sensitivity trigger such that all fish would be captured but minimize the recording of false events such as debris or a change in lighting conditions. The shed over top of the counting chamber did not block out sunlight entirely. Therefore as the sun changed angles it also changed the lighting conditions for the cameras. Once the sun had set light was provided by an incandescent light (150 watt) located in the ceiling of the shed and by the LED lights provided by the cameras themselves. In order for the system to work effectively it is apparent that a controlled lighted system will work best. This is described in more detail below.

The weir provided good infrastructure for mounting the cameras and providing controlled passage of the fish. However once fish passed through the weir they were confined to a holding pen on the upstream side in order that they could be sampled for size, gender and aged (scale sampling). This often resulted in much turbulence downstream from both the fish and the samplers. The turbulence in the water resulted in many false events being recorded. For the video surveillance system to work more effectively it would be better to deploy it where there are no upstream disturbances occurring

The most prevalent problem encountered during the 2004 trials was the recording of false events. The security spy software employed during the trials is triggered to record an event as a result of motion. Motion in the field of view is determined by the software by comparing the degree of pixelation changes that occur from one frame to the next.

The software is unable to determine what causes the change in pixelation but only the degree of the change. Whether or not the change in pixels from one frame to the other triggers a recording is then determined by the sensitivity settings. Sensitivity can be set by the operator. As a fish is relatively large compared to much of the debris moving down the river sensitivity can be set as to eliminate the recording of much of this debris. If the cameras are set in an area where there is much turbulence in the water at the camera site or immediately upstream it is not possible to set it such that all fish movement is recorded yet no false events are recorded. Therefore the surveillance system should be placed at a location where very little if any turbulence is occurring upstream. During these trials the cameras were located in the fish passage chamber of the counting weir. The chamber is located downstream of a pen used to contain fish that have just passed through the weir so that they could be sampled. This resulted in much turbulence in the passage chamber and the recording of numerous false events.

Data Storage

A concern encountered during the 2004 trials was data storage. The lap-tops used in this study came with a CD burner. However due to the large number of false events captured during the trials it was not always possible to burn all of the data to one CD alone and at times the hard-drive would become overloaded when the trial was left to accumulate data for more then 24 hours. However once the number of false events is minimised data storage should not be as challenging except possibly during days of peak migration in high volume years.

In place of using CD's to store the data if the system is used at a location that will result in large numbers of fish passing through it may be more practical to use a computer with a DVD burner or to dump the data directly onto a "memory stick' or external hard-drive. This would allow for the placement of one computer at the counting location and leave it in place for the duration of the trials or period of enumeration. Data from each counting session can be transferred to the "memory stick" and transferred to an office based computer for analysis and/or permanent storage. "Sticks" are now available with up to 4 gigabytes of memory.

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2005 Program

For the 2005 trials the equipment to be used was similar as in the 2004 trials except a camera box (described in more detail below) was developed for use at this site and the new site at Village Creek was not equipped with a generator. Therefore a solar power system was ordered to provide the power required for the system. Eight weeks lead time was provided to get the panels delivered however numerous problems were encountered when trying to obtain the panels. First the initial order was very late in shipping. The panels were being shipped from California and then on to the Yukon via a distributor in Victoria, B.C. When the first shipment arrived in Victoria the arrived damaged and therefore were not forwarded to the Yukon. Therefore a second order was placed however due to the very high demand for the panels a second shipment could not be expedited immediately resulting in further delay to the program. When the shipment did finally arrive the came equipped with the wrong type of cables required for the system design. This resulted in a further delay until early August at which time most of the fish that migrate through Village Creek had already past by the counting weir.

While waiting for the solar power system to arrive the camera box system was set up at the counting weir. It was placed upstream of the electronic counter but butted up against the counter. Cameras were put in place and tested (fully charged batteries were used initially in order to test the system. Cables from the cameras were buried up to the tree that housed the batteries, computer and peripherals for the system. The system was left in position for several weeks while waiting for the solar panels and proper cables to arrive. The counting box remained stable in its position in the creek and for the most part a grizzly bear that frequents the site on a daily basis did not tamper with the equipment, at least not in a way that was damaging. However once all the equipment to deploy the solar power generating system arrived the bear tampered with the equipment that was instream resulting in damage to the camera cables. At this point the team working on the system was no longer available to work on it and it was decided that the trials should be deferred until 2006.

Controlled Camera Box

A major factor triggering false recording events during the 2004 trials was lighting conditions. Light reflecting and refracting through the water creates a change in pixelation on the computer such that false events are recorded. Although the system was enclosed in a covered shed in 2004 light bouncing off the water still interfered with the surveillance system.

In order to minimise problems associated with lighting and to offer protection to the cameras a camera box system was designed that would allow passage of the salmon and offer protection to the cameras while reducing problems associated with changing light conditions. As the cameras come equipped with their own light system it is not necessary to allow external daylight into the box.

The box (36” wide x 36” long x 12” high) (see Appendix 2) is fabricated of 3/16 aluminum with a removable cover to give access to the cameras. The camera chambers are isolated from the salmon passage route with plexiglass. Camera mounts were permanently installed in the box that allows for the cameras to slide vertically but do not allow for rotation of the cameras from left to right. A relatively heavy guage aluminium was used as bears frequent the site where it will be used and thus must be able to support the weight of a large bear.

Underwater Camera Box (salmon swim through box from bottom to top of photo). Cameras can be mounted on either side of the box protected by internal plexiglass walls

Alternative Power Supply

In the event that the surveillance system is to be located in a remote location where operation/placement of a gas powered generator is not possible or desired alternative energy supply is an option. These include solar, water or wind. The most practical/reliable of these three energy sources is solar and micro-hydro although wind energy could be used at the right location. Solar power will be used to power the system at the Village Creek site.

Solar

Solar powered systems are widely available on the market and have proven to be a reliable means to provide power for systems that do not demand a large amount of power. In order to power the surveillance system as described here using up to four cameras requires about 85 watts of continuous power. The system needs to operate 24 hours a day.

Solar panels or photovoltaic (PV) cells come in a variety of sizes, types and power production capabilities. They however can only provide power during periods of daylight. On days when there is heavy cloud cover the amount of energy that can be produced is reduced. Therefore and the energy storage system needs to take in account days that may not provide a lot of energy.

The amount of energy available from the sun is also a factor of the time of year with most of the energy available during the summer months and the maximum amount available around the summer solstice (i.e. June 21^{st}).

Based on a constant consumption of 85 watts of power the underwater surveillance system described here will consume about 2.0 kilowatts of energy per day or 2,000 watt-hours/day. Based on a 80-100 watt rated panel producing energy for an average 6 hours/day up to four panels would be required. However as there will be days when power production is compromised due to weather and therefore an extra two-four panels should be designed into the system as well as extra battery storage (see battery storage section).

Battery Storage

The surveillance system consumes approximately 2,000 watt-hours per day. Using the number of panels recommended above, six 80-100 watt panels, up to 3600 watt-hours can be generated over a six hour day of sunlight. Therefore more energy will be produced on a sunny day then will be consumed. The excess energy can be stored in a battery bank and used on a cloudy day when the sun does not provide enough energy to match what is consumed on any given day. The actual amount of storage required needs to take into account the possible number of consecutive days that solar energy may not be available.

In this situation it is recommended to have up to three days of storage capacity. Therefore, considering the system will consume approximately 2,000 watt-hours per day, or 170 Amp hours (2,000 watts / 12 volts), about 500 Amp hours of storage should be used. The batteries should be a high quality deep-cycle battery. Deep cycle batteries are better suited for situations where they are charged and de-charged frequently. Based on a recommended 500 Amp hours of storage four batteries of 150 Amp-hours or three at 175 Amp-hours should be used.

Micro-hydro

As the underwater video salmon enumeration system will likely be deployed on a stream or river it is possible to use the energy of the flowing water to provide power. Very small micro-hydro generators are available on the market that can produce a continuous supply of power in the 100-200 watt range. This would work very well for this type of system. The amount of power available is a function of head (elevation drop. A variety of options are available from Energy Systems and Design in New Brunswick (microhydropower.com). These can be very reliable for providing power. The main drawback for this type of system is that a water use license would be required before it could be installed unless a run of the river system is employed.

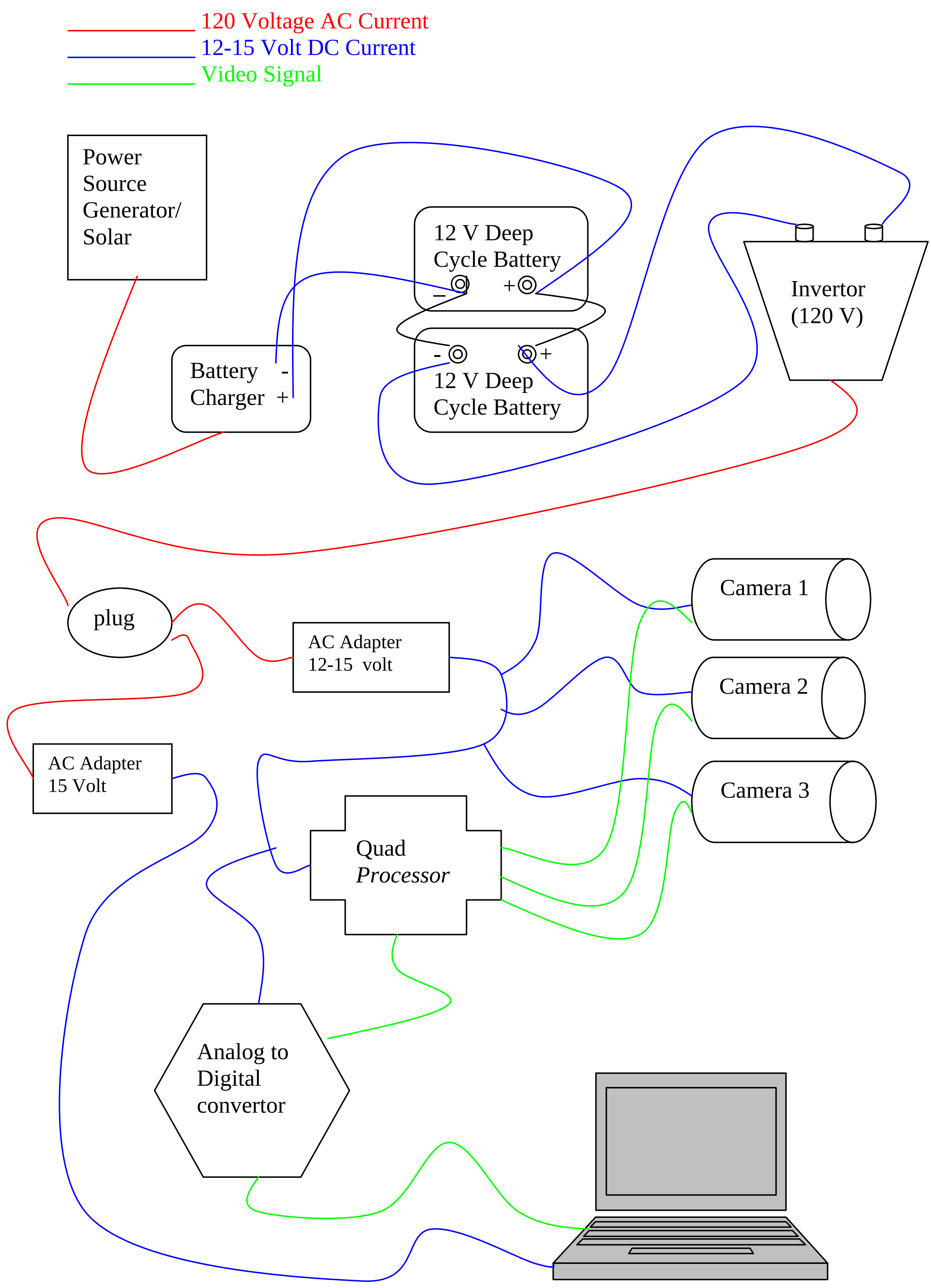
Run of the river systems are only practical where a relatively swift current (i.e. jogging speed) is available.

Ongoing Research

In September of 2006 Linaya Workman of CAFN and David Petkovich attended the 135th Annual Meeting of the American Fisheries Society in Anchorage Alaska. A series of oral presentations were given pertaining to the use of video technology for fisheries applications. Several of the presentations focussed on the use of video technology to enumerate salmon in northern remote locations. It was valuable to compare the technology being used in this project to what others are doing and experiencing with their trials in the field. It was determined that others testing this technology in the field are using similar techniques and encountering similar problems with its application. In other words it appears that this program is on the "right" or "similar" track. Others experimenting with this technology are successfully using solar and wind power to provide energy to the system. There also seems to be a tendency to record continuously rather then using motion detection software. Continuous recording however requires much more time committed to data review as well as much more hard-drive space to store the recorded events.

Champagne and Aishihik First Nations is planning on continuing the trials during the summer of 2006. All the equipment for conducting the trials has been obtained which should facilitate a timely set-up for the trials. The Village Creek site provides and ideal location to run the trials. A weir is established there on an annual basis, the site is easy to access, the water is relatively clear and the site is frequented by bears which allows for the opportunity to test the bear "proofness" of the gear and set-up. Additionally there is an electronic counter at the site and combined with the video equipment the two systems will serve as a truthing mechanism for each other.

Appendix 1: CAFN Underwater Video Surveillance System – Power and Video Signal Pathways



Appendix 2: Schematic of Camera Box used in 2005 Trials