Rampart Rapids Full Season Video Monitoring 2010

Using a Fish Wheel on the Yukon River

By Stan Zuray

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Annual Report to the Yukon River Panel, Anchorage, Alaska

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Cover (clockwise from top left – all 2010 pictures): 1. Looking out on the river from Rapids camp 2. Rapids Video fish wheel. 3. Mom and daughters cutting king strips and edibles at Rapids. 4. 20 mile fish camp fishers getting ready to cut king salmon.

Author

Stan Zuray has been a fisherman and trapper in the Tanana area since 1973. Since 1996 he has run fish wheels for a number of monitoring projects at the Rampart Rapids. He is one of the developers of the fish wheel video system currently in use on a number of Yukon River drainage fish wheels.

Sponsorship

This project was funded by a grant from the US/Canada Restoration and Enhancement Fund.

The Rampart Rapids video fishwheel project continues a close working relationship with the USFWS Field Office in Fairbanks. USFWS provided a biologist who has a partnership relationship with this project and USFWS provides yearly funding contributions for in season computer and assessment assistance and postseason analysis related to the video project data some of which is included in this report.

The Tanana Tribal Council provides fax and copying services for the project. They also help arrange travel and logistics for students who come to work with the video and data projects as in 2010.

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Thanks to Fisheries Biologist Dave Daum (USFWS) who provided invaluable preseason computer support, in-season help, and postseason analyses of collected data. He is currently the major developer of the video capture system installed on the Rampart Rapids video fish wheel. His support is funded by the Restoration and Enhancement Fund, Project Number URE-08N-10.

Thanks to the USFWS Fairbanks Field Office and their many biologists and workers who continue to make this project a success.

Thanks to the Alaska Sustainable Salmon Fund Steering Committee for funding the Student Data Collection Project at Rapids. This adds greatly to the scope of this video project and provides data needed to determine a start date for the fall chum salmon video counting.

Disclaimer

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Abstract

Long-term monitoring of major salmon stocks is a necessary component of successful fisheries management on the Yukon River. The Rampart Rapids video fish wheel project presently provides the only U.S. main stem Yukon River assessment database of run strength and relative abundance of Chinook and chum salmon in 1000 miles of river. Many of these stocks are bound for spawning grounds in Canada and contribute to international treaty obligations. Since 2000, the project has provided daily catch data of salmon and migratory whitefish species to fisheries managers throughout the Yukon drainage.

The project's fish wheel design and construction incorporates features that reduce injury to fish. The installed video system allows fish to be immediately released back into the water, eliminating stress from live box holding and handling. Fish wheel operation and location is maintained in a consistent manner from year to year using a list of standards, so more meaningful comparisons and interpretations can be made. The video technology allows precise and reliable collection of catch-per-unit-effort data. Daily in-season update reports, which include daily species catch data information and run timing, have been distributed to managers and interested persons from 2005 to 2010.

Introduction

Monitoring of Chinook salmon (*Oncorhynchus tshawytscha*) passage in the middle Yukon River began in 1999 at Rampart Rapids 730 miles upstream from the Yukon River mouth. Before this time, there were no U.S. run assessment projects for mainstem Yukon River Chinook salmon above Pilot Station, 138 miles from the mouth to the U.S./Canada Border. This unmonitored area covered over 1,000 miles. Numerous subsistence and commercial fishermen harvest salmon along this section of river. In 1999 daily subsistence fish wheel Chinook salmon catch–per-unit-effort (CPUE) was supplied to the Alaska Department of Fish and Game (ADF&G) by satellite phone from the Rapids. Chum salmon monitoring began in 1996 with the United States Fish and Wildlife Service (USFWS) as part of a mark-recapture project. From 2000 to 2010, daily catch rates of Chinook and chum salmon (*O. keta*), sheefish (*Stenodus leucichthys*), humpback whitefish (*Coregonus pidschian*), broad whitefish (*C. nasus*), and cisco species (*C. laurettae and C. sardinella*) were reported. Data on Chinook salmon and the numerous other fish species that are important subsistence resources caught at Rapids will help build a long-term population trend database that will increase in value as the project continues. The Restoration and Enhancement Fund directed by the Yukon River Panel has been the major source of funding for this project over the years.

The project site at the Rapids has probably been a subsistence fish wheel site since fish wheels came to the Yukon around 1900. The particular bend in the river where this site is located has always been well known for its ability to consistently produce good catches of fish, Chinook as well as chum salmon, whether the water was high or low. Because of the unique currents in the Rapids, fish wheels are capable of being run there even during the spring drift that happens at the same time as the Chinook salmon run. Traditionally, people would travel to the Rapids area to spend their summers because of these qualities. Even today it is one of the most densely populated active fish camp areas on the Yukon River.

Fish wheels are a common capture method for management and research activities in the Yukon River drainage. Specifically, fish wheels have provided CPUE data at various locations to fishery managers. Also, fish wheels are used to capture and hold fish for tagging studies. Most of these fish wheels use live boxes to hold fish until the researchers or contractors process and release them, and crowding and holding times greater than four hours is common. A growing body of data suggests delayed mortality and reduced traveling rates are associated with holding, crowding, and/or repeated re-capture (Bromaghin and Underwood 2003, 2004; Bromaghin et al. 2004; Underwood et al. 2004). The video capture techniques developed and used by this project have less of an impact when counting fish.

From 1996 to 2005 the site had been used to run fish wheels for the U.S. Fish and Wildlife Service (USFWS) Rampart Rapids fall chum salmon tagging project (Apodaca et al. 2004). During these years limited (hours varied) CPUE data was collected by the USFWS on chum salmon. From 2000 to present video fish wheel projects at the site have been run to provide CPUE data on all species present in the fish wheels catch. During these 15 years the site fish wheel has operated with only 2 down days, both due to heavy driftwood flow.

In 1997, 1998 and 1999 a fall chum salmon radio-tagging project was conducted by the National Marine Fisheries Service at this site. During the first year of operation the radio tag project became aware of a possible problem with live box held chum salmon. This problem was studied in 1998 and 1999 and project results (not yet published) showed a significant negative effect on fish held in the live box for 4 to 6 hours (J. Eiler, National Marine Fisheries Service, personal communication).

In the fall of 1999, a development project was undertaken at this site to address the increasing concerns over live box held fish and devise an alternative method of monitoring catch using video (Zuray and Underwood 1999). Video technology, as an alternative to live boxes, avoids all of the handling and live box crowding issues by eliminating the use of live boxes altogether. Video systems have been used in counting windows at dams in the Columbia River basin for several years (Hatch et al. 1998). These systems have proved to efficiently provide accurate counts. They have, however, been designed for use in developed areas where standard power is available and environmental variables are easily controlled. To transfer this technology to a fish wheel on the Yukon River, it was necessary to deal with many problems that did not exist in prior applications of this technology. A video capture system was developed that had low DC power requirements (Daum 2005). The system used an analog Charge Coupled Device (CCD) camera, mounted above the fish wheel chute. As fish slide down the fish wheel chute, they were recorded to a time-lapse VCR in 12-hour recording mode. The fish images were then extracted from the VCR tape and digitized using Salmonsoft video capture software. Fish were tallied by species and CPUE data were generated (see the methods section of Zuray and Underwood 1999 for a detailed description of the original video methods). Over the years this system has been modified and improved. Also, a specially built fish wheel was used that had many features designed to reduce possible injury to fish. The USFWS Fairbanks Field Office was directly involved in the development and support of the Rapids CPUE video project in 1999

In 2000, a Chinook and fall chum salmon CPUE video project was funded at the Rapids site by the Restoration and Enhancement Fund. Catches of sheefish, humpback whitefish, broad whitefish, and cisco species were also monitored. These video projects were run without any live box held fish released back into the river and were the first projects of this kind ever run. From 2001 to 2003, the USFWS Office of Subsistence Management funded operation of the Chinook salmon video project as a means of producing data in a way much less harmful to fish (Zuray 2003). Restoration and Enhancement Fund monies continued to fund fall chum salmon video projects in 2001 and 2002 (Zuray 2002a, 2002c, 2003). In 2003 Rapids Research Center funded the fall chum salmon video project due to a lack of outside funding. From 2004 to 2010 the Restoration and Enhancement Fund gave money to the Chinook and fall chum salmon full season video project at the Rapids (Zuray 2004, 2005, 2006, 2007, 2008, 2009). As requested by the Yukon River Panel, these projects provided monitoring of the whole season for all species present.

Objectives

1. To provide daily fish wheel/video catch-per-unit-effort (CPUE) data on Chinook, summer chum, and fall chum salmon, and migratory whitefish.
2. To continue improving fish-friendly fish wheel capture techniques and equipment.
3. To continue developing methods for adjusting raw catch data that takes into account factors such as river discharge, fish wheel catch efficiency and small versus large size Chinook salmon yearly variations.

Study Area

The project was conducted 40 miles upriver from the village of Tanana, Alaska at an area locally known as “The Rapids”, a narrow canyon 1,176 km (730 miles) from the mouth of the Yukon River. The fish wheel is located on the left (south) bank. Traditionally and at the present time this area is known for its abundance and variety of fish species. This condition exists because of the currents and steep banks that force fish to migrate through the area relatively concentrated and close to shore. Fish wheel sites have been established for many years in the area, so no site conflicts occurred. The unique protection offered by the site, from wind, high water, and spring river drift allow fish wheels to run with little or no down time.

Methods

In the following methods section I often write about past years procedures and equipment. It is done to provide a historical account and explains reasons for the improvements that have taken place over the years. The goal is to keep each years report as complete a manual as possible for anyone wanting to look into video capture systems. Also some of what is past to this project is currently in use at other video fish wheel sites out of necessity because of site conditions.

Fish Wheel Operation

A two-basket fish wheel equipped with a video capture system was used to count salmon and other species in 2010. Effort was taken so the operation of the project was consistent from year to year. The fish wheel rotation speed, basket dip depth, distance from the basket to river bottom, and length of the lead fence were kept similar between years. Basket width was 10 feet and dip was kept around 13 feet. Nylon seine netting was installed on the sides of the baskets to minimize injury to fish as they were lifted clear of the water. Plastic vinyl covered mesh was placed on the bed or sliding portion of the baskets for “fish friendly” operation. Underwater holding boxes that were used for subsistence by the operator and as a means of catching fish for research activities that the project supported were 8’ long, 4’ deep and 2 ½’ feet wide. 2 ½” holes were drilled throughout the live box to allow a continuous flow of water while reducing current inside the box.

Chinook Salmon Season

The fish wheel was put in the water during the first week of June and assembled in running order within a week. The water generator and associated electronics gear were mounted on the wheel. By mid-June all of the electronic gear to be used in the video project was mounted on the fish wheel or set up back at camp. This included the surveillance camera, portable monitor, laptop and desktop computers, two generators, the data transmitter and receiver.

The first Chinook salmon arrive historically, as early as mid June or as late as the first week of July. Because of the large amount of subsistence gear in the river at the Rapids before arrival of Chinook salmon and the applicants own participation in this fishery, monitoring the arrival of the first fish is always easy. Each year, nets are in the water at the Rapids in early June, before the first Chinook arrive, and ADF&G’s Pilot Station sonar data are monitored for run timing. Within a day or so of the first reported fish caught anywhere in this section of river the Rapids test wheel starts counting and assembling the data in electronic and graph form. Collection of chum salmon, sheefish, and broad, humpback and cisco whitefish data started at this time also.

Secchi disk readings related to fish wheel efficiency testing are started at this time as are the daily fish discharge tables from the Yukon River Bridge and in season wheel temperature readings. More accurate temperature data loggers (post season available only) were placed on the lead fence at the top (1 m depth) and bottom (4.3 m depth) to evaluate any temperature differences throughout the day between the two. This is a continuing attempt to look into the reasons for the diel catch patterns that exists at the wheel and any possible relation to fish movement.

The schedule for running the wheel during Chinook salmon season was 12 hours per day, 6 days per week (excluding Sundays). This schedule was originally worked out in a discussion with Keith Shultz (Area Manager) of the ADF&G in 2000. The reasons for this schedule are as follows:

1. Because of the high amount of drift in the river at this time of year, continuous nighttime (unattended) running of the fish wheel is not advisable. This was the case in 2000 and 2001 and some of 2006, 2008 and 2009.
2. Twelve hours running time would reduce the amount of Chinook salmon processed by the wheel yet still provide the data needed.
3. The logistics of one person running a site 40 miles from the nearest town necessitate one day a week being used for a supply trip to Tanana. Note: during the last few years of the project very few of these "supply days" are needed and in general we have been able to operate 7 days a week.

Fall Chum Salmon Season

During the fall season some changes take place in the operation of the project. The date this project used for the official fall chum salmon arrival in 2010 was August 4. Traditional ecological knowledge derived from elders in this area and the addition of some scientific principles of data collection is used to determine arrival time. This date is different than the set date used each year by Federal and State managers. The arrival of fall chum salmon is determined by viewing the flesh of the fish as they are cut in the subsistence fishery. As the fall season approaches, the percent of chum salmon having bright red color in the flesh, a distinguishing characteristic of fall chum salmon is recorded. When the percentage rises abruptly to 50% or more it is considered that the fall chum run is solidly underway. This method of thinking is prevalent in the subsistence fishery of this area and is used in place of a set date.

Start up date for the fall project is August 1 unless significant numbers of fall chum salmon are detected earlier. The proposed schedule for running is 24 hours per day (minus time needed for normal maintenance, data transfer, etc. each day). The project runs six days per week (see below). Project shut down coincides with the declining numbers of the last fall chum salmon pulse (September 15 – September 25) or if icing conditions are severe. Reasons for schedule are as follows:

1. Twenty four hours sampling would maximize the amount of data collection time and be in line with recommendations from ADF&G for operation of the Rapids fall chum salmon CPUE project.
2. Logistics of one person running a site 40 miles from the nearest town necessitate one day a week being needed for a supply trip to Tanana and occasional equipment repairs or changes. As demonstrated during the Chinook and fall chum salmon projects from 2000 to 2010, data are collected on these off days when trips or repairs are not needed.

Project Specifications

This section provides specifications on fish wheel components and operation so CPUE results in future years may be comparable. Changes in some of these could easily make these comparisons meaningless. Because of shifting silt deposits and unstable banks sites, some projects are not able to collect data consistently using these specifications from one year to the next. The Rapids has a hard rock bottom and the same site can be used each year. The specifications listed below are kept as consistent as possible each year and notes were made any year that was not possible.

1. Basket dip (amount of basket in water when vertical) is 13 feet (12 ½ to 13 ½).
2. Width of basket (outside to outside) is 10 feet.
3. Lead fence length is 20 feet.
4. Wheel is two-basket design with a basket side height on the lead facing side of 5 feet
5. Wheel baskets are always run between one and 1.5 feet off bottom (hitting the rocky bottom can be disastrous).
6. Basket rotation speed is approximately one to 1.5 turns per minute. This slow speed is part of the fish friendly operation and is controlled by sets of easily removable paddleboards. Desired rotation is described as "just a little faster than stalled".

Video System

The video system used consisted of a color CCD camera mounted above the fish wheel chute and directly connected to a wireless microwave transmitter mounted on the back of the fish wheel and aimed downstream toward the camp site. At camp the wireless receiver is connected to a laptop computer through a video capture card. After the fish wheel captured the fish, they were video recorded as they traveled down a chute, and then re-entered the river. A time-lapse VCR and/or second computer were occasionally linked to the system for assessment work and video recording backup. Twelve-volt batteries powered the system at the fish wheel. During daytime operation, a water-wheel generator charged the batteries. In fall at night, floodlights necessitated the use of a small generator.

This system differed substantially from what was used in the development year of 1999 and the first full project year of 2000. In 1999 and 2000 the camera was attached directly to the time-lapse VCR using 12-hour recording mode. These tapes were taken back to camp and run through a capture program (Salmonsoft Vcap 1.07) to extract the video frames that contained fish into digital avi format files. This process took two hours per 12-hour tape. The software program pulled the fish images out of the VCR tape with a "luminescence trigger" that used the change in pixel brightness between the background and the passing fish image. The system worked fairly well as long as any sources of strong shadow and light was eliminated from the viewing area. The major limitations of this method were: 1) the frame rate was limited to 5 frames per sec, 2) camera positioning was limited by the background (no shadows), 3) the system could only be run for 12 hour periods, and 4) VCR tapes would take an additional two hours of processing before digital files could be counted for fish.

In 2001, Dave Daum (USFWS) developed a new system that improved past limitations of the system (Daum 2005). A camera was mounted directly to a laptop computer on the fish wheel. The computer had a new version of Salmonsoft software (funded by USFWS) that used electronic triggers to initiate capture of fish images as they slid down the fish wheel chute. A lightweight door was installed at the bottom of the chute with a magnetic switch attached. When a fish exiting the chute opened the door, a signal was sent to the computer. Frame rate and numbers of frames captured before and after the triggering event were controlled by software so the limitation of using time-lapse tapes was eliminated. In the late 2006 season an infrared electronic trigger was tested and installed. Since then to 2010 again this method was used for the entire season successfully.

A plywood shack with wood stove was constructed in camp in 2001 and was used to house the equipment and process the data each year since.

Daily Video Procedures

The following is a list of daily 2010 video procedures followed at the fish wheel (this gives a general idea only as these procedures change over the season):

Start up

- Turn on camp laptop, microwave receiver, and start software capture program.
- Arrival at the fish wheel - make sure wheel is adjusted for running (the most complicated part).
- Switch on power to water generator and lower into water. Turn on fish wheel.
- Open electronics cabinet, turn on DC power from batteries, and turn on camera and microwave transmitter.
- Check portable monitor to make sure camera is on, in focus and positioned (rarely changes so this is not done daily).
- Wipe window clean on camera case (splash marks) and clean chute background (for nice pictures).
- Start official counting by manually tripping capture system while holding a start sign in camera view.
- Wet fingers and wipe infrared lenses of silt and fish spatter.

Shut down

(12 hours later: at least one trip was made to wheel mid-day and often more when drift was heavy).

- Manually trip the capture system while holding a stop sign in camera view.
- Lift water generator out of water and turn off DC current to water generator.
- Turn off fish wheel and lift baskets up to protect from nighttime drift.

Fish Counting

In 1999 and 2000 time-lapse VCR 12-hour tapes were brought back to camp and run through Salmonsoft's "luminescence" program to digitize the fish images to electronic video format (avi). This process took two hours. Avi files were viewed through a Windows media player and hand-tallied. We were unable to adjust scroll speed while viewing video and all numbers of fish by species and sample times had to be entered into the database by hand.

In 2001, an electronic tally system was developed to facilitate rapid counting and calculating of CPUE data by fish species. This video counting system, Salmonsoft capture review program, allowed tallying of individual fish species using a computer keyboard and is what was used in 2010. Images could be reviewed at user-defined speeds and played forward or reverse for review. USFWS funded the new software development.

Fish are enumerated by species and daily CPUE calculated for each species. Catch numbers, comparison graphs and subsistence information were reported daily by emailed to approx 120 persons requesting the daily updates. These include managers, biologists, subsistence fishermen and other interested persons. A shorter update with basic raw data only is supplied daily to ADF&G to satisfy more official requirements. Permanent video CD files are made of all fish caught by the fish wheel for back up, later research needs, and project assessment work. Inseason and past project data is also available on the project web site. From 2003 to 2007 a totally separate luminescence capture program was run one day a week for inseason assessment purposes. The results of each were compared as a means of detecting problems. We also decided to drop the daily backup using VCR tapes because lack of system failures warranted less backup effort. Since 2008 we have relied on daily assessments of the system performed at the wheel and checked during the normal evening counting. This meant an additional daily chore but was fairly simple and most important provided a daily check of operations.

Assessment of Capture Program

Before 2008, to assess the video capture system, segments of separate luminescence program counts were viewed and compared to the corresponding video capture files generated from the magnetic or infrared switch video system. The luminescence program counts contain fish that pass through the chute captured in an entirely different manner than the trigger method, so assessing how many fish, if any, were missed by the trigger method was a fairly straightforward process although rather tedious and boring. Selection of assessment samples had two parts. A day was selected based mostly on weather, which would optimize the luminescence programs operation. 2. The first six hours or the first 50 fish was selected to review (based on workload in reviewing that much material). The process was as follows:

1. The luminescence program AVI file for a particular day was played into a computer software program called Salmonsoft Review that simply opened up a window on the monitor for viewing. This window was moved onto one half of the monitor screen.
2. On the other half of the screen the AVI file made by the fish wheel laptop/switch program was opened using Salmonsoft Review program
3. Both viewing samples were set at the beginning of the assessment sample period. The regular program controls, the computer mouse and keyboard forward and reverse features were used for viewing the AVI file from this point on.
4. The trigger AVI file was advanced to the first fish, stopped and the time stamp noted.
5. The luminescence program AVI was run forward until a fish appeared and paused.
6. If all went well the trigger AVI fish and the luminescence program AVI fish should be the same and have corresponding times. The operator looked for a fish on one frame and not the other. This situation would signify a miss by the laptop/switch program or the luminescence program.
7. Each fish reviewed was counted on a tally sheet.
8. Misses are recorded on the tally sheets in case further study is needed to see why the error occurred, however most of the time the reason was apparent.
9. The AVI file was advanced to the next fish and the process then repeated.

Starting in 2008 and again in 2010 system assessment was accomplished first at the wheel by running a hand through the infrared beam a set number of times (10-20). Speed and time between hand passes was varied and exaggerated to find any variable which could cause a missed capture. At the evening fish counting time, the same numbers of captures were watched for with the object being that a missed capture would mean a potential problem. In 2010 no problems were detected. This simplified yet more thorough method is able to be used because of the infrared trigger system presently used. The prior method is still in use on non infrared wheels in the drainage.

Power Equipment

Aquair UW propeller driven water generator: This generator had very little output for the water speed encountered at the fish wheel (approximately. 6-8 ft/sec.). It could only produce 1-2 amps. Because the project was sometimes run in only the daytime hours (no lights needed), the camera, laptop, and VCR were able to run without a supplemental generator and keep a full charge on the batteries. Its use is recommended only after carefully assessing the water current at each site, power needs of the project, cost ($2000.00) and work of setting up. On a positive note it seems to be a durable, continuous use piece of equipment, lasting 10 years and only had to replace shaft seals twice.

Honda 1000 watt generator (EU1000I): The color video camera running at higher shutter speeds required about 180 watts of light at night (fall time only) to produce a nice picture. This plus other equipment (camera, VCR, and inverter) came to under 300 watts, which this generator easily handled, on a lower RPM setting that this generator was equipped with. This efficiency boosted gas economy to 10 hours per 0.61 gallons. An extended gas supply was run into the generator's carburetor for more use without refueling. When not in use the extended gas supply was lowered to a level below the generator to avoid possible problems associated with a leaking carburetor needle valve. Another method was also used where the fuel supply was run into the generator fuel pump. It required more dismantling of the generator but the fuel supply could then be kept at a level lower than the generator. Although not necessary a timer switch was wired into the generator so the generator would shut off whenever desired. The generator was light and ran on the shore in a converted doghouse with an open front and a 6" square hole in the back for the exhaust to blow out. A 100' extension cord ran from shore along the fish wheel spar pole to the equipment enclosure. A number of generators have had to be replaced over the years (about 1 per year) and overall they don't seem to hold up to the extreme long run times the project requires. Since 2008 a similar but larger 2000-watt generator was used. According to Honda these larger units come with steel cylinder sleeves and do seem to last considerably longer.

Honda 2500-watt generator (EB2500): used at camp to run the desktop computer. It ran all the camp equipment easily and was very quiet and dependable.

Water Turbine: Built by Energy Systems and Design LTD this was installed in the beginning of the season and completely replaced all camp power needs provided by the above 2500 watt gas generator. It was extremely carefree and payed for itself in the first year by requiring no gas to be used at camp. Cost was about $2500 for the bare unit. Of note however is that we already had a battery bank, inverter and water pipeline in camp. All that is also necessary to use the water turbine and a camp having to buy that could spend considerably more.

Batteries: four 6-volt deep cycle batteries supplied the stored 12-volt DC power. Although fewer batteries could be used, a generator shut down could necessitate the use of this much reserve power to keep the video running. The reserve allowed for minimal use of the water generator on days when drift was especially bad. The batteries all sat neatly in an inexpensive waterproof plastic tote in the bottom of the equipment enclosure.

Battery charger: a 10/30/50 amp (Schumacher SE-1250), taper charge, automobile type, charger was used. The charger will run constant at 8 amps at night with lights on. Plans are to someday go to a charge controller specifically made for constant use (the auto type chargers are not designed for continuous use).

Inverter for wheel light and electrics: an inexpensive 150-watt modified sine wave inverter worked well and drew minimum watts in past years. A 300 watt modified sine wave inverter was used also and had the advantage of a power off switch. These inverters were replaced occasionally (every few years) because of durability problems. Spares were always on hand. In 2009 we switched to a pure sine wave model (3 times as expensive) which is used to produce the best electricity for the infrared and capture devices.

Lights: two 90-watt halogen 27^{0} beam GE floodlights. One was run off an inverter from the DC batteries in case the gas generator system ever shut down. The other light ran directly off the generator in case the DC inverter system failed. Each light had an adjustable light sensor wired in and was quite workable with each light turning on independent of the other as darkness progressed. During a generator, light, or inverter failure, one light could produce a dark yet fully countable video. I found these to last the length of time stated by the manufacturer and changed them each year before they would fail. In 2010 after much experimentation was done with LED and fluorescent lights we switch to two LED and one halogen lights.

Fish Wheel Chute

On wheels equipped with live boxes a "chute" is used to pass the fish from the wheel baskets over the raft logs and into the live box. Wheel sites do exist that do not require vertical adjustments to the axle; this site however required adjustment in times of lower water. The chute, therefore, had to be adjustable in that it must go up and down to match up to the changing level of the baskets or fish injuries increase from fish dropping rather than sliding into the chute. This means the camera, enclosed sides of the chute, and the chute must be one unit to eliminate refocuses of camera, especially in bad weather, in times when the wheel axle/baskets are needed to be raised. The chute enclosure in 2000 was the source of some of the greatest trials and tribulations (Zuray 2000, 2001a). In 2001 the laptop/switch method developed, with the help of Dave Daum, eliminated the need for all the sunlight and wind blocking structures of the fish wheel chute. The bottom (viewing area) of the chute was lined with white UHMW 1/4'' thick plastic. It was easily cleaned and stayed white, the preferred color background for the video images.

Chute Door/ Magnetic Switch

A door made of 1/4-inch plywood covered with 3/8-inch thick closed cell foam was constructed to fit over the exit area of the camera chute. The magnet that activated the trigger switch was mounted on the door. The switch itself was mounted in a stationary position adjacent to the magnet. When the door moved outward approximately three inches the magnetic field around the switch weakened sufficiently to close the switch. This sent an electrical current to a serial interface that in turn communicated the switch event with the computer. The door was hinged on top with fish exiting out the bottom. The operation of the door had to be light enough so that even small whitefish could open it, and at the same time, it had to close positively without bouncing when large fish passed. A bouncing door could cause the switch to open again after a fish had passed, resulting in empty frames captured. A 2-foot wooden rod was attached to the top of the door and acted as a counter-balance. The rod was attached by a length of nylon cord that passed through a pulley to a weight suspended in an "ABS" plastic pipe filled with a water/anti-freeze mixture for all weather use. The weight was made of a plastic pill bottle filled with the solution and some lead shot. The action of the weight, dampened by its movement through the liquid, caused the door to slow down just before it reached the closed position, providing bounce-free operation. This system, developed on site, worked very well but required considerable trial and error to install correctly. The length of the handle, the height of the pulley, and the amount of shot used for weight are factors to be synchronized. This dampening system was necessary because of vast differences in the way a 1/2-pound cisco and a 50-pound Chinook salmon went through a hinged door. A buzzer was installed in-line with the switch to provide an audible indicator that the switch was working. In 2003 a simple wind counterbalance was installed at the top of the 2' wooden rod on the chute door that removed much of the false door openings cause by heavy wind. This system was used till mid season 2006.

Other Tested Triggering Devices

The magnetic switch has been a reliable triggering device since its initial installation in 2001. But certain environmental conditions have been problematic at times and required innovative fixes. During windy conditions, the door opens prematurely, tripping the switch, and allowing fish to pass by the camera undetected. The door hinge has broken due to stress from large fish slamming into the door frame resulting in the door falling off and fish passing undetected. The mechanical magnetic switch has a limited number of "trips" before the contact points fail and video capture is compromised. Small fish species, especially ciscos do not consistently open the door due to their small size, resulting in missing (approx 5%) some small fish. Because of these minor problems, there has been a concerted effort to find another triggering system that is more reliable, less affected by various environmental conditions, and able to detect even the smallest fish. An added incentive for continually looking for better methods is the technology becomes simpler to move to other projects.

Thru-beam ultrasonic sensor: In 2005, a thru-beam ultrasonic sensor was purchased and tested. The sensor consists of one transmit and one receive transducer. After bench testing, the sensor was installed on opposite sides of the chute and field tested. Results were somewhat encouraging, but wind along the surface of either transducer caused the switch to falsely trip. Also, since the sensor was made up of only one narrow beam, depending on placement, some fish could slide under or over the beam undetected. A single-shot timer was installed on the switch so the duration of the electrical output (after being tripped) could be controlled and lengthened. This allowed the software (Salmonsoft) to react consistently when the switch was tripped. This method has never been used for real time counting.

LED light screen sensor: In 2006, a light screen sensor was purchased and tested. The light screen sensing system consists of two self-contained units: an emitter and receiver. The emitter has multiple infrared LEDs spaced at 9.5 mm increments, and the receiver has corresponding photodiodes. The sensor was installed on opposite sides of the chute, resulting in a cross-hatched optical pattern covering all areas of the chute from the bottom to seven inches above the surface. With this almost complete coverage, target detection issues would hopefully be eliminated. A laser rifle-sighting device was used to align the two units during installation. The lens of each unit was cleaned once per day of fish slime and silt to keep the sensor functioning properly. Silicone had to be applied to each unit to more effectively seal the sensor screen from moisture and prevent lens fogging.

Methods for testing the light screen sensor in-season were developed and implemented in 2006. From July 12 through August 21, 2006 the sensor was installed in the video chute with a bright red LED attached to the sensor switch. If a fish passed through the light screen, the light would turn on for a set amount of time controlled by the single-shot timer (see above). The red light was installed in the field of view of the video camera. If a fish was video captured by the original video system using the chute door/magnetic switch, the captured picture would also include a record of the red light being tripped by the light screen. During video file review and fish counting, a record was kept to evaluate if the red light from the screen sensor was activated each time a fish was captured by the video system. On August 22, 2006 the light screen sensor was installed as the triggering device for the actual video system on the fish wheel, thus removing the chute door/magnetic switch from the system. The new light screen sensor was then run for the rest of the season. Regular assessment methods were used to evaluate if any fish were missed using the new light sensor during this testing period (see Assessment of Capture Program, Methods). From 2007 to 2010 this method was used successfully all season and a new improved video chute was built around the sensors which easily allowed for small aiming adjustments to be made.

Fish Wheel Construction

It is counterproductive to install a video system only to have fish injured by the fish wheel unnecessarily. The fish wheel used was specially built to try to eliminate injuries. Basket sides have seine webbing and no braces creating a sort of trampoline in the critical areas. The basket bed was lined with 1 ½ inch x 1 ½ inch high-density plastic webbing in 2001 and 2002 and 1" x 1" vinyl coated wire in 2003 to present. All entrance and exit doors are lined with closed-cell foam. Easily removable paddleboards of different sizes allow much control of the fish wheel rotation speed. Rotation needs to be consistent with no prolonged hesitations but should not be so fast as to lift the fish high before it has a chance to migrate towards the basket chutes. In 2003 to present basket chutes were completely lined with durable 5/16" closed cell foam that was contact cemented to the chute boards. This produced dramatic results in the reduction and for all practical purposes the elimination of bloody gills in Chinook. In 2007 an almost exact duplicate of the 2006 wheel was finished and used and run all season. While some changes were made relative to strength and wear all the wheel specifications required by the project such as basket dip and width, etc. were used and continue to present.

Electronics

Camera and Lens: Panasonic color 1/3" format CCTV camera: (model WV-CP474 with 480 lines horizontal). This camera has many user selectable features including shutter speed that was critical for providing quality images. The camera has 12-volt DC power input and standard BNC video connectors for video output. This camera used in 2001-2007 produced noticeably better images than the similar model WV-CP464 used in 2000. Numerous lenses are available. The lens is a Computar, vari-focus model TG3Z271FCS, 2.7-8mm,F1.0 TV lens, color camera. A nice piece of equipment new in 2002, improved the pictures that made the system work. The color, zoom and focus capabilities of this camera were essential features. The camera, mounts, and waterproof case were under $1000. A waterproof camera housing was necessary and we kept a good amount of silica gel in it at all times to absorb any water vapor trapped inside the case (Pelco Surveillance Camera Housing).

Monitor: a 3"x 5" color LCD monitor wired to the 12 volt system and the video output provided a picture of the camera's view for focusing, zooming, and positioning and camera parameter settings at the fish wheel. All of these of course needed to be done on the wheel. It was supplied with 6-ft long wires and could be put right next to the camera during these adjustments for easy viewing.

Video Recorders: these are presently used only for our backup system. Video cameras are connected to a 12 volt DC video recorder (Panasonic AG-1070dc) with 12 and 24-hour time-lapse capability. The video recorder is placed in a waterproof Pelican case and wires ran to the outside via waterproof connectors. The video recorder stores images on the videotape at a rate of approximately 5 frames per second on the 12 hour setting and it has a date and time stamp feature that is used at all times. A matching, second video recorder at camp is available to play images into the video capture card/computer for final luminescence capture. These VCRs have factory-cleaning recommendations of every 60 hours. This model of VCR is no longer manufactured. These are still running fine and kept available for instant installation in the event of a trigger system failure.

Desktop Computer: a desktop computer was used in camp to download video files from the fish wheel video system, review and tally fish, capture fish from VCR tapes, and organize data in spreadsheets and graphs. The computer has a 3.20 GHz Pentium 4 processor, 1024 MB 400 MHz of DDR SDRAM memory, Windows XP operating system, Recordable/Rewriteable DVD RW/ R/CD-RW, analog PCI video capture card, and multiple card reader installed. The card reader was used to download the video files from the IBM micro-drive. All files were backed up on compact disk. This computer was new in 2004.

Laptop: The laptops used from 2000 to 2007 were Panasonic Toughbooks CF-48. They were the only laptop found that was capable of running on straight 12-volt current. The laptop had a Pentium III 700 Mhz processor, Windows 98 and XP operating system, 20 GB hard drive, 500 MB of SDRAM, and an 8 MB video card. An IBM 1 GB micro-drive was used to move video files from the laptop to the camp's desktop computer. In 2008 the video fish capture was taken over by a Lenovo 3000 V200. It has a dual core 1.50GHZ CPU and 990 MHZ, .99 GB of RAM and runs Windows XP. This upgrade is a pleasure to work with and allows multiple operations to run at once without any danger to interrupting capture program operations as in older laptops.

Capture and video review software: Salmonsoft capture software Vcap 1.4.0 was used to capture fish images off the fish wheel. The software allowed use of a trigger switch to record fish images as they slide down the fish wheel chute. In camp, video files (AVI format) were reviewed and tallied using Salmonsoft viewing software Vcap Rev 1.4.0. This software could view video files, play files forward and reverse using user controlled scroll speeds, and tally fish with user defined keyboard keys.

Wireless Video Communications System: Model CS-300 made by Premier Wireless Inc. In 2002 this 5.8 Mhz microwave transmitter and receiver were used to experiment with sending the video signal from the fish wheel to camp 1/2 mile away. The objective was to run the system for the entire fall season along side the existing video capture system to see how it performed in various environmental conditions, i.e., wind, rain, and fog. The system performed flawlessly in 2002 and the complete system was installed and ran on the fish wheel from 2003 to 2007 thereby eliminating the need for having the laptop capture system on the fish wheel. All video capture was done back at camp. This reduced power requirements at the fish wheel, reducing amp/hr usage from approximately 3.4 to around 0.5 amp/hr. Along with the advantages realized in normal use of this wireless system, the ability to run multiple capture systems, both luminescence and magnetic trigger initiated ones, for experimentation purposes, has been greatly enhanced. Having multiple unproven systems on the fish wheel would be difficult in many regards. With wireless this experimentation can be done at camp. In the 2004 season we ran 2 trigger systems with different operating systems and one luminescence system for assessment. In 2005 to 2008 the wireless allowed testing of multiple capture triggers (ultrasonic and infrared) while running the main counting system uninterrupted. The wireless video system made this much simpler and is still running fine. It is very expensive ($4,000) and is one of the few components that we do not have a spare of. This is okay as we have an on the wheel backup system ready to be deployed at any time.

Project Related Areas of Study

Flesh color and fall chum salmon arrival: The summer chum run in this section of the river is relatively small in number and is made up of chum salmon whose fat reserves are low (most are close to their spawning areas) and therefore their flesh color is very pale in roughly 90% of the population. These chum salmon are of much lesser value for people and dog food. With the arrival of the fall chum salmon in late July and early August a distinct and unmistakable change takes place. What happens is in a matter of 3-5 days (occasionally longer) after the summer run has been providing people with consistent 10% red flesh fish, the percent of red fleshed fish will rise progressively to 50 - 75% or as high as 90% (mostly depending on the amount of summer chum salmon still running and mixing in). The “official” start date for the video project begins when the red flesh color passes the 50% point. This method has supplied Rapids video project with the most accurate date to start counting fall chum each year since 2000. Presently no other method including genetic analysis has replaced it.

Fish wheel efficiency and discharge adjustments: Rapids test fishwheel adjustments are made by taking 24 hour video counts and adjusting that number using a formula that takes into account the speed of the current at the fish wheel. It is much more accurate than comparing traditional CPUE value at this site because of the varied influence of water height and speed on the migrating fish. This then gives a number similar to a daily passage estimate. At this site it is possible to do this by monitoring USGS discharge or water height readings taken upriver at the Yukon River Bridge, as those readings have a linear relationship to the site current speed. The basic idea for this is born of fishers’ traditional knowledge that as current speed increases fish have the tendency to move closer to the banks (and are more susceptible to shore based gear such as fish wheels) to avoid the increased flow, and the fish will spread out and away from the shore as speed decreases. There are two key things that have made this type of adjustment easier here. One is that there is never a time when the water raises that the speed of the current does not also increase, or water lower and the current speed decrease. This was shown by in-situ velocity readings taken over two summers and is not the norm for many fish wheel sites which often have periods of faster or slower current speeds unrelated to water discharge. Second is that for 10 years the site was also contracted to catch fall chum salmon for a USFWS tagging project producing a weekly population estimate. This gave the video project many weekly “efficiency of fish wheel in different water discharges, data points” which were used to construct a workable formula. The method has not been tested with statistical rigor, however yearly passage estimates produced by the method compare remarkably well to independent passage estimates from Rampart fall chum salmon tagging project and run reconstruction estimates from 1996-2005 (Figure 9). Presently because of the use of increasingly more accurate sonar methods and equipment used to assess Upper Yukon escapement in a number of projects, there is a need to make adjustments to the Rapids discharge formula. These adjustments will be simple to make but will require an estimation by the upriver projects of the fish counting efficiency gain they have achieved with the new methods. We are currently waiting on those estimations of efficiency gain to be made before we make changes to the discharge formula.

Water temperature: Onset StowAway TidbiT© water temperature data loggers were installed at the fish wheel for the duration of the fishing season. The temperature sensors were installed on the fish wheel lead at about 1 m and 4.3 m depth. Measurements were taken daily at 1 h intervals and mean daily water temperature was calculated by averaging the hourly readings. These measurements were taken from 2003 to 2010 in an effort to provide more temperature data collection on the Yukon River and to explore possible effects on fish wheel efficiency that temperature variations might have and to have temperature correlation data for the *Ichthyophonus* disease studies at the Rapids. The two temperature sensors (post season data available only) placed on the lead fence at the top and bottom also allowed us to evaluate any temperature differences throughout the day between the two. This was an attempt to look into the reasons for the diel catch patterns that exist at the wheel and any possible relationship to fish movement. A manual readout temperature gauge was also placed on the fish wheel to provide daily readings inseason. While not as accurate it did provide temperature data that was used to correlate with the inseason *Ichthyophonus* research the project was involved with and provided general temperature trends for the Yukon River Drainage Fisheries Association (YRDFA) teleconferences.

Diel catch patterns: These patterns are not at present available for Chinook salmon due to the lack of sufficient numbers of captured Chinook salmon, large amount of days containing hours with no Chinook salmon captured and 12-hour project run time. While the existing data have been looked at with interest, the project is unable to present any statistically valid diel patterns at this time. The project's equipment and time has supported this type of effort on the fall chum salmon run which typically starts during the latter part of the project. Seasonal mean hourly catch rates were calculated from days with 24 h of continuous data for fall chum salmon. First, hourly catch rates (fish/h) were calculated for all hours in each day. These hourly catch rates were expressed as proportions (%) of the daily catch so high catch days did not bias results. Then mean catch rates (%) by hour were calculated for the season. Only days with catches of over 100 fish were used to minimize using hours with no fish captured. This is another part of the work being done to explore movements of fish as it relates to the operations of the video project in an attempt to make the project more consistent and accurate. It was decided in 2006 that we had run enough years of diel data (2003-2006) to prove the existence of a consistent diel pattern at the fish wheel and that no more was necessary at this point. Past years data are included in this report as it is an important consideration of fish movement past the fish wheel. If any need arises in the future, for diel rates from any year, archived video data can be run to produce the diel graphs, etc.

Water turbidity: A standard Secchi disk was used to take daily readings on water clarity changes in the Yukon River at the Rapids starting in 2003. This was done in a shaded area about 10' away from shore. Water clarity is known to affect fish capture and this was another area being explored for its effect on catch efficiency at the Rapids fish wheel.

Video fish sizing: The similarity in overall Chinook salmon numbers in 2002 and 2003 for the Rapids project drew our attention because the project operator did not feel the 2002 and 2003 runs were similar in strength at all. The overall number was the one most used in the past to measure run strength. The runs were also not viewed as similar in strength by any of the subsistence fishermen in the Tanana and Rapids area fish camps, which numbered about fifteen. This accelerated an ongoing investigation into just how extreme the abundance or absence of small Chinook salmon in a population can affect the projects assessment of run strength.

Starting in 2003, length measurement marks in the video chute have allowed classification of Chinook salmon into small or large salmon based on length (< 70 cm total length = small). Though not as accurate as manual measurements, the marked chute provides a way to differentiate between two size-classes of fish. Separating the Chinook salmon run into these two components was believed to give a better picture of the run when comparing its catch to other assessment projects. Because the video chute in 2002 had the same marks as the 2003 chute, the 2002 Chinook salmon video avi files were recounted separating the small and large fish. The results were dramatic and show just how far off a run assessment can be if some small separation technique is not employed. For example, the total number of Chinook salmon captured at Rampart Rapids video project was just over 1,600 fish in both 2002 and 2003, but when the small and large Chinook salmon are separated one sees a catch of large Chinook salmon ≥70 cm total length) in 2003 that is 67% higher than 2002. When the run is looked at from this perspective a very different picture in terms of fish numbers and pounds available to Chinook salmon net fishermen, pounds available to wheel fishermen, and escapement of large fish (females) headed to the spawning grounds emerges.

Thus, by having the ability to separate the Chinook salmon run into the two size components, the result is a better understanding of the run characteristics and true strength. Future project plans are to continue developing the reporting method that includes the accuracies of the separation technique and to continue work on developing a digital measuring method to accurately measure individual fish with the help of Dave Daum (USFWS).

Results and Discussion

The project operated for 96 days in 2010 with one down day due to heavy drift in river. The project operated on all of the scheduled days off (Sundays) except for two needed for travel and/or maintenance issues. Project started counting on June 16 and continued through the last major chum salmon pulse ending on September 20.

The project's 24-hour CPUE for Chinook salmon, summer chum and whitefish are summarized in Tables 2 through 5. Adjustment of fall chum salmon CPUE based on discharge continued in 2010 with the daily release of graphed adjustments made to interested fisheries managers.

Dave Daum of the USFWS Fairbanks Field Office (R&E project URE-08-10) again worked closely with the video project. During two site visits, technical operations of the video system were examined. In 2010 major work was centered on a small hydro turbine installation which has replaced 99% of camp power needs and the costs of gasoline associated with that means of power. His work is supported by the R&E fund.

The video project's computers and equipment were again donated to assist in the 2010 Student Data Collection Project which collects data on a full season of Chinook salmon and also fall chum salmon arrival data. This project is funded by the Alaska Sustainable Salmon Fund.

Chinook salmon.

The project had a cumulative CPUE of 793 Chinook salmon. This is the lowest cumulative CPUE in the project's 11 years with the next lowest being 1008 in 2007. Average CPUE for all project years is 2399 Chinook salmon. Correlation to the CPUE and estimates at the lower Yukon assessment projects was slightly on the low side probably due to the very low water and resulting low catch efficiency at the fishwheel site during Chinook salmon season. Each site and gear has different reactions to water level and current speed and the Rapids project site is known for low count efficiency in low water.

This year, the pulses moved upriver from the lower river at normal travel rates. Increased water current and temperature variations are understood to influence travel rates. Chinook salmon took an average of 16 days to arrive from the set net project near the mouth of the Yukon. This yielded an average of 46 miles a day travel speed. (Figures 1 through 3). The mid-point of the Chinook salmon run in 2010 was July 10 which was five days later than average.

The 2010 run was composed of 43% percent small (< 70 cm total length) Chinook salmon (in 2009 it was 8%). In the eight years of operating the Chinook salmon video chute fish sizing component, this was a high proportion for small Chinook salmon compared to past project years (Figures 4 and 5) with only 2002 being made up of more small fish (45%).

The primary objective of the project is to collect CPUE data in a consistent manner year to year. The Chinook and chum salmon CPUE data are presently of the most interest to fishery management agencies (ADF&G, USFWS, and Department of Fisheries and Oceans (DFO) Canada). These data are only meaningful in as far as they relate accurately to actual salmon passing through the site area. That actual number is of course not available for comparison so other established Chinook and chum salmon assessment and escapement projects on the river are looked at and compared for indications of project accuracy with respect to run-timing and abundance.

Below (Table 1), the project is compared to four major Chinook salmon projects in the Yukon River drainage that have been operating consistently over time (See figure 6 also). The video project is 11 years old so only years 2000-2010 are compared. All below 2010 data from other projects should be considered preliminary.

Table 1

Year	24 hr. expanded Rapids cumulative All	**Large	Lower River Set Net cumulative CPUE	Pilot Sonar estimates	DFO Border Tag estimates	Eagle Sonar
2000	1708		14.12	70,112	16,995	
2001	5563		15.23	137,453	54,029	*(started*
2002	1667	911 (55%)	20.23	183,505	43,359	*2005)*
2003	1646	1351 (82%)	27.06	253,774	58,082	
2004	2854	2000 (70%)	20.48	188,874	48,500	
2005	2061	1485 (72%)	17.8	143,997	45,000	81,528
2006	2917	1891 (65%)	21.81	168,351	47,965	73,691
2007	1008	657 (65%)	19.21	125,553	22,958	41,182
2008	1622	1238 (76%)	22.27	130,643	*(project*	38,428
2009	2937	2702 (92%)	11.51	122,474	*ended in*	69,957
2010	790	450 (57%)	18.67	114,300	*2007)*	34,603

*Some 2010 figures may still be preliminary
** Large ≥ 70 cm total length

Chum salmon.

Chum salmon projects available for comparison are much more numerous; some use weirs and small stream sonar. A comparison technique used by fisheries biologists for looking at upper Yukon chum salmon passage above the Tanana River involves adding together escapement projects, harvest, and border passage to evaluate how that estimate compares with in season monitoring projects. This project uses that method to evaluate its yearly discharge adjusted index or estimated passage of chum salmon at the Rapids site (Figure 7 to 9). Estimates for years 1996 to 2005 show a very close comparison using the projects discharge adjusted formula. Estimated in this manner, the total fall chum salmon run size past Rapids this year was 193,107 fish (299,130 in 2009). Looking at all project years from 1996 to 2010, 11 years were higher and 2 were lower. Presently, because of the use of increasingly more accurate sonar methods and equipment used to assess Upper Yukon escapement in a number of projects since 2005, there is a need to make adjustments to the Rapids discharge formula to keep it in line with the post season estimate. With that in mind, this project views the 193,107 estimate as somewhat low relative to present day upper river project assessments, but quite suitable for comparisons to this projects figures in past years.

Based on chum salmon passage data from July 21 through September 20 2010 the midpoint of the run based on the unadjusted number was on August 31 while based on the number adjusted for discharge was September 5, five days later. Making this adjustment for discharge in season helps to compare to the projects farther upriver and gives a more realistic assessment of changes in migration pattern particularly in years when high water plays an important role in arrival times

In 2010 the daily Rapids CPUE correlated well with Lower River net CPUE at Emmonak and Mt Village. There was good correlation to Pilot Sonar project estimates also. Upriver at the Chandalar Sonar correlation was good also but Eagle sonar numbers were noticeably higher than usual relative to Rapids video project estimates (see Figures 10 to 12 for com.

In 2010 the early fall pulse of chum salmon, known locally as the brights or silvers, reached a fair sized CPUE of 450 to 650 fish per day (in test wheel) for about one week. Pulse one is always the most valued for people and dog food; the fish are at their fullest and their flesh is the richest. Every subsequent pulse has declining amounts of these qualities with the front side of each individual pulse having higher quality fish and the backside having the poorer quality fish. The first small numbers of fall chum salmon arrived around July 31st with increasing numbers about August 4th. Chum salmon numbers continued to rise and by the end of the first week of September were peaking at an estimated 8,000 fish per day through Rapids. This “pulse” continued and slowly declined to around 2,000 fish per day when the project shut down on September 20th. These last chum salmon were the normal low fat, lack of red flesh color, and water marked fish. This year, all the pulses seemed to move upriver from Pilot Sonar at a similar travel rate. Chum salmon took an average of 25 days to arrive, which yielded an average of 24 miles a day travel speed which is relatively very slow. This was probably due to very high water periods during their travel upriver in 2010.

Flesh color and fall chum salmon arrival: In 2010 the Rapids Student Data Collection Project determined a fall chum salmon arrival date of August 4th. The first sign of fall chum salmon arrival was a small increase in CPUE and quick rise in the percent of red fleshed fish. By August 4th the red fleshed chum rate rose past the 50% mark (to 75%). This project starts counting all chums as fall chum salmon after that 50% point is reached (Figures 13 and 14 show graphs of past large studies on this).

Other fish species. Occasionally pike, burbot, grayling, coho salmon, suckers, and lamprey are recorded in the fish wheel. Their numbers are always small from 0 per year (as in pike and grayling) to 30 (as in Coho). Other fish include Bering cisco, broad whitefish, humpback whitefish and sheefish. (Figures 15 to 18).

Diel catch patterns. Continuation of this study is considered unnecessary at present. Raw data capable of analyzing diel patterns will be taken and archived each year in case there is ever a future need to further study it. See figures 19 to 21 for past site results of this study.

Fish wheel efficiency mode: The relationship between discharge levels and the catch efficiency of the Rapids video project is still being explored. and Dave Daum, USFWS. Currently CPUE is only adjusted by discharge for fall chum salmon. It may be that Chinook salmon being of larger size and greater swimming power may have a different relationship. Analyses continue to show a strong linear correlation between discharge and fish wheel efficiency with chum salmon. From 2004 to 2010 discharge adjusted fall chum salmon data were sent in daily with the normal CPUE data to state and federal managers.

Daily chum salmon numbers are adjusted, using a fish wheel efficiency model related to daily water discharge. This adjusted passage index continues to be studied and formula upgrades investigated each season. The results continue to appear to be much more inline with other Yukon run assessment projects than the unadjusted CPUE. In 2010 because of the large number of high water days (Figure 22), during when the last half of the fall run passed, project assessment counts would have been higher than they were had the CPUE not been adjusted.

Water temperature: Daily mean water temperature during the 2010 project varied from a high of 18.6 °C on July 11 to a low of 9.4 °C on September 20 (Figure 23). The maximum hourly reading was 19.1 °C on July 11 and the lowest hourly reading was 9.3 °C on September 20. Within a day, hourly water temperatures varied by less than 1 °C. The highest readings were generally between 2000 and 0100 and lowest readings between 1000 and 1400 each day. Relative to 2003 – 2009, 2010 temperatures varied considerably, with a cold period in mid-July, warm during beginning of August, and warm throughout September (Figure 24). As with other years, temperatures were highly influenced by local weather conditions. The comparison testing done using temperature loggers placed on the top (1 m depth) and bottom (4.3 m depth) of the fish wheel lead fence showed a thorough mixing of the water throughout the day and season (Figure 25). The cause of the diel movement patterns of fall chum salmon documented in the 2003 – 2005 analysis remains a mystery. At this time, water temperature at different times of the day and at different water depths does not appear to be a factor influencing fish movement. Further studies relating to changes in water temperature at different distances offshore may provide additional insight.

Water turbidity. Secchi Disk readings responded to rises in river levels and the normal melting of glacial streams from high temperature days early in the season. Colder temperatures of the advancing fall weather, lowering of the water level and subsequent clearing of the river are seen in the data also (Table 6).

Video system components: The video system continues to be very accurate at counting fish that were captured by the fish wheel. Many of the potential fish handling problems associated with fish wheel capture have been eliminated by the development of this method.

The video capture system used in 2010 has many improvements over the original system used in 2000. With the introduction of the infrared sensors for fish video capture in late 2006 and 2007 even the small cisco whitefish can be counted accurately. Cisco capture accuracy assessment figures show only a 98% capture success rate in 2004 and 95% in 2005 for instance.

The fourth full season run of the light screen sensor in 2010 was successful. Of additional interest, passing flies and moths were video captured using the screen sensor, indicating the extreme sensitivity to small passing objects. Windy conditions never caused the screen sensor to trigger. In 2007 one extreme rain event during which 3 ½" of rain fell in about one hour, the sensor did capture a few unneeded empty frames which was no problem. The testing and evaluation of the screen sensor has demonstrated that the new sensor is a definite improvement over the chute door/magnetic switch.

Finding the best software program settings to control the amount of frames captured before and after the infrared sensor was tripped was a matter of trial and error during testing but usually does not change after that. A setting to capture more frames than was necessary would mean larger than needed file sizes and more time spent reviewing video files. Settings that do not capture enough frames can cause some fish to be missed either because they were not recorded at all or there were so few frames in the video file that human error came into play during the review process. Software settings are influenced by the goals of each project.

This video project is primarily used at present to provide CPUE data, with fish needing to be identified to species. Projects that attempt to measure, sex, or view spaghetti tags on salmon may need the number of frames collected increased to provide more opportunity to view the fish in various orientations as it flops/slides through the apparatus. Because of the improved software review program, that provides the capability of controlling the speed, more frames captured for each fish does not substantially slow down the overall counting process. The increase in file size this may cause is of small consequence considering the storage capacity of the laptop hard drive, micro drive transfer disk and final storage on CD-R disks. In 2007, the introduction of a new chute for infrared fish detection and its change in placement to more mid video chute caused adjustment to these settings in the course of experimentation and testing.

A good software review program is important for accurate and timely counting of captured fish. The ability of the software to allow reverse, stop and forward control from the keyboard became more important as the numbers of fish counted in a day increases. For example in some years chum salmon catches can approach 2,000-4,000 fish per day. At high numbers such as these every refinement becomes meaningful, not just to speed up the process but also to reduce operator error.

Operation of the laptop computer, interface, electronic components, software program, VCR, and camera all worked well enough in 2010 that data was collected every scheduled day except for August 16th on which heavy drift filled the river. Running longer into the evening or using our backup luminescence video capture system solved the few problems threatening the loss of data.

The building and maintenance of the fish wheel chute door was greatly simplified in 2001 and 2002 and again in 2007. Construction techniques still require attention; because its operation is critical to the proper triggering of the laptop capture system. In 2010 a rebuild of the video chute (due to UHMW plastic sunlight deterioration) took place.

Figures 26 and 27 show some of our chute and project operation pictures.

Past video system testing: A mechanical triggered video system, developed during the 2001 to 2004 Rapids video projects, has been installed and tested on four fish wheels operated in the Yukon River drainage. Two wheels were used for monitoring daily catch during the summer and fall season and two wheels were used for counting tagged and untagged salmon for mark-recapture experiments. As of spring of 2004 the video system operated for over 14,000 hours and recorded over 262,000 fish images. Salmon species (Chinook, chum, and coho salmon) were the most common species captured (235,962), followed by Bering and Least Cisco (14,746), and sheefish (7,145). Data were collected on total operation time, number of fish captured by species, and type and number of system failures. Throughout the testing period, comparisons were made between fish counted from the switch-triggered video files to: 1) fish collected in the fish wheel live boxes, or 2) fish recorded on time-lapse videotape. A video review program, Salmonsoft Fish Review, was used to tally fish by species from the digitized video files. Live box captured and time-lapse recorded fish were tallied by hand. Digitized and time-lapse recordings were synchronized and each frame was time-stamped so similar time segments could be compared.

During the multi year testing period, comparisons between numbers of fish recorded from the triggered video system were similar to fish recorded on time-lapse videotape and fish captured in fish wheel live boxes. A total of 357 hours of fish wheel capture were recorded on videotape and 1,794 hours from live boxes. Compared to time-lapse recordings, the video system missed 34 of 3,462 fish (1%) that passed down the video chute. Of the 34 missed fish, 22 were small cisco species that passed under the exit door without triggering the switch and 12 salmon were missed because the software capture settings for frames captured before the trigger event needed to be increased to allow for multiple fish captures i.e., more than one fish sliding down the chute at once. Subsequent adjustments to the door and software capture settings eliminated undercounting by the video system. Compared to live box capture, the triggered video system recorded 660 additional fish, i.e., of the 19,499 fish recorded using the switch program, 18,839 were counted in the live box. Fish jumping out of the live box before counting began and data recording errors explained the difference

Partnerships and Capacity Development

The Rapids video project continued a close working relationship with the USFWS office in Fairbanks. Their biologist and video technician Dave Daum has made trips each season to help with operations of the video CPUE project and to assist in assessing those operations. This work is currently supported by R&E funding. Rapids video projects in 1999 through 2010 have also served as a center for research into fish friendly video development, low fish impact fish wheel improvements, and run assessment improvements related to diel catch patterns, water discharge and clarity effects on catch efficiency, by the project manager and the Fairbanks US Fish and Wildlife Service Field Office.

In all years, the project has always been open to the public and any agency personnel. A number of people from the USFWS and ADF&G view the workings of the project each summer. ADF&G is the primary point for the daily reporting of data from the 2010 project.

Prior to 2005, very limited reporting of the projects data, by any agency, existed. In response to a growing number of requests for the data, I started a daily e-mail distribution list. The list presently includes about 120 persons, with names continuously being added again this summer as requests were received. This daily email update is small in size and reports the raw CPUE video project data only. It is used for official reporting and for those with limited email bandwidth. Its efforts are funded by this project.

This video projects funding also supports efforts to get it's data disseminated by way of other agencies and organizations email updates and websites. In those instances project data will often be included in or with comments, summaries, graphs and tables not supported by video project funding.

Since 2007 project information has been available in the Yukon River update section of the State ADF&G site (http://www.cf.adfg.state.ak.us/region3/yukhome.php). Project information and past reports, etc. are also available on a local web site (www.RapidsResearch.com) and on the email updates put out in season by ADF&G and DFO. None of the above websites or emails are supported by video project funding.

The Student Data Collection Project has operated at Rapids since 2001, with this video project as a main partner. From 2001 to 2005 the USFWS Office of Subsistence Management was the main funder. U.S./Canada Yukon River Panel Restoration and Enhancement monies through a YRDFA and an ADF&G run project did fund a smaller collection project to keep this database going in 2006 and 2007. The information collected comes from a full season sampling effort of up to 1000 Chinook salmon each year. At many USFWS regional council meetings, YRDFA meetings, and state advisory council meetings that take place each year these data are described as very important. Video project computers, generators and lots of other equipment are donated to helping this project. While the mandatory ASL data collection of R&E funded projects does not apply to this video project because of its immediate release of the counted fish, the project is directly involved with this effort through the above partnership. In 2008, the data collection project was fully funded by a three year AYK SSI grant and continued video project support. This partnership work has been resubmitted for funding for 2011 to 2013.

Each year the video project supports a number of research activities by other individuals or agencies. Figure 28 in this report show some of this capacity development effort. Almost all are completely voluntary efforts of this project. These have included:

1. *Ichthyophonus* research by Dr. Richard Kocan and Paul Herschberger in 2001 and 2002.
2. The contaminants in salmon study by Keith Mueller and Angela Matz, USFWS, in 2001.
3. A 2003 Bering cisco data and otolith sample effort for Randy Brown of the USFWS Fairbanks Field Office.
4. A whitefish radio telemetry project by Bill Carter of the USFWS Fairbanks Field Office in 2002 and 2003.
5. In 2004 and 2005, a Bioelectrical Impedance Analysis project designed to investigate bio-energetic features (body fat, water retention, etc) in migrating salmon was conducted at Rapids working in conjunction with biologists from the Fairbanks Fish and Wildlife Field Office, Keith Cox from West Virginia University, Kyle Hartman from West Virginia University, and Joe Margraff from the University of Alaska, Fairbanks.
6. In 2005, with students from the data collection project, genetic samples and data from whitefish species were collected for biologists with the Department of Fisheries and Oceans Canada.
7. The video system developed at the Rapids project has been transferred to and currently operates on the Tanana River sub district 5A test fish wheel (Fliris, B. 2000), Rampart fall chum salmon tag recapture fish wheel (USFWS ended 2005) and the Nenana test fish wheel (ADF&G, Borba 2007) Numerous other inquires have been made from other river systems and the technology has been adjusted to operate at weirs and counting towers.
8. In 2006 the project facilitated Chinook salmon scale and genetic fin clip sampling at Rapids for ADF&G.

9. In 2006, *Ichthyophonus* heart samples for YRDFA's PCR testing.
10. 2006 provided a platform for radio tagging of Bering cisco whitefish by Randy Brown and Dave Daum (USFWS).
11. In 2007, Chinook salmon fin clips (771) were taken for genetic ID information for ADF&G.
12. In 2007, Burbot fin clips were taken for genetic ID information for USFWS
13. In 2008, 1000 Chinook salmon genetic fin clips were taken for Bonnie Borba at ADF&G in Fairbanks
14. In 2008, 450 Chinook heart samples were taken for Lara Dehn for postseason histology and PCR laboratory workup (ADF&G).
15. In 2008, Randy Brown (USFWS, Fairbanks) requested and was sent sheefish genetic fin clips for his continuing whitefish work.
16. In 2009, collected over 500 Chinook fin clips for genetic ID for Bonnie Borba (ADF&G)
17. In 2009 collected requested bering cisco data and fin clips (150) for Randy Brown (USFWS).
18. In 2009 students assisted a salmon contaminates study by providing samples and labor for the USFWS study personnel (Chris Latty).
19. In 2010 450 chum genetic and data samplings were taken for ADF&G Fairbanks (Bonnie Borba)
20. In 2010, collected 970 Chinook fin clips for genetic ID for ADF&G (Bonnie Borba)
21. In 2010 450 chum salmon genetic and data samplings were taken for Bonnie Borba (ADF&G, Fairbanks) to look at traditional ecological knowledge based on flesh color
22. In 2010, Randy Brown (USFWS, Fairbanks) was sent 200 genetic fin clips and related dissection data for his continuing whitefish work.
23. In 2010 video project helped collect all species of whitefish genetic, aging and lifecycle data with Bill Carter from USFWS Fairbanks office. Data was for a number of researchers.

The Rapids Video Project continues to be the major source of developmental work in video technology and fish friendly fish wheel monitoring methods.

The site of this work can be seen in the map provided (Figure 29).

Conclusions

1. CPUE data can be dependably generated by a fish wheel live box alternative such as a video capture system.

2. Workable and often inexpensive improvements to a fish wheels construction and operation can dramatically reduce injury to sampled fish.

Recommendations

1. CPUE data is only valuable to the degree it is a reflection of what is actually happening in the river. To this end the Rapids video project maintains a list of project components that may influence CPUE data (see Project Specifications on page 10). Future projects at this site should incorporate these specifications to aid in more accurate data collection and interpretation.

2. Each year this project provides local fishermen with run timing and run strength information verbally through bulletin board postings in the community of Tanana and daily email updates. In the past it was often difficult to consistently find the data. The State, Federal and private projects (such as this one) all had different mechanisms and variable success for getting data to the public. Project managers, fishermen, and concerned persons need to have the data in a timely manner to assess their own projects, know when fish pulses are arriving, and provide information to YRDFA representatives for weekly teleconferences. For many years I recommended that I would like to see an Internet web site or someone charged with sending out emails updated with the daily numbers and information from all projects on the Yukon River. I am grateful to see ADF&G has taken this on for the fourth summer. Data dissemination is particularly important for the early and midseason Chinook salmon run. I recommend this continue in future years.

Budget Summary

Total Cost: 46,100 (1 year project)   Project Dates: June 1 to September 25, 2010:

a. Total Annual Budget	46,100
b. Expenditures thru December	46,100
c. Balance thru December	0
d. Anticipated Remaining Expenditures	0
e. Anticipated Final Balance	0

Additional information: No alterations to the budget were necessary.

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<u>Note on data in the following Figures and Tables</u>

All data from other projects shown in the following comparison graphs should be considered preliminary. Work on this report starts long before many projects have finalized their data.

Figure 1

Lower Yukon Set Net CPUE Compared to Rapids Video CPUE
Chinook 2010 (Rapids Research Center)

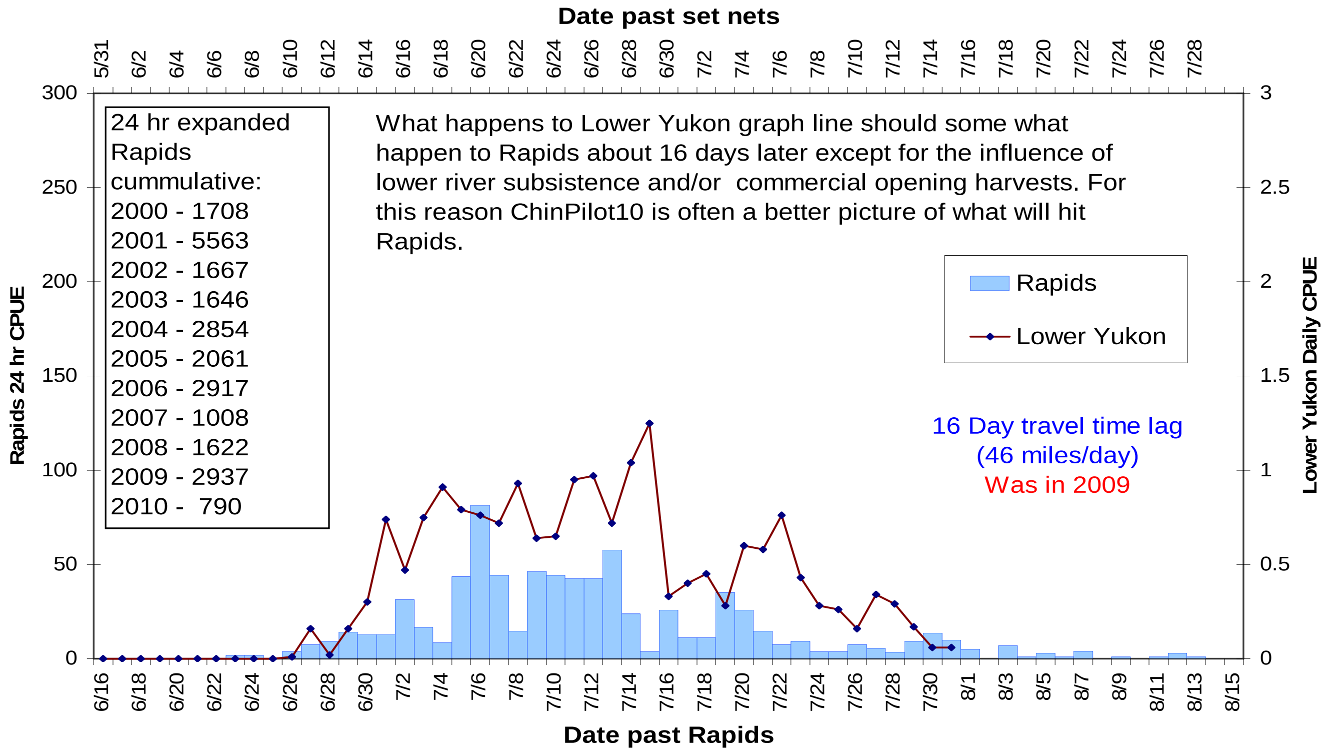


Figure 2

Pilot Sonar Estimates Compared to Rapids Video 24 HR CPUE
Chinook 2010 (Rapids Research Center)

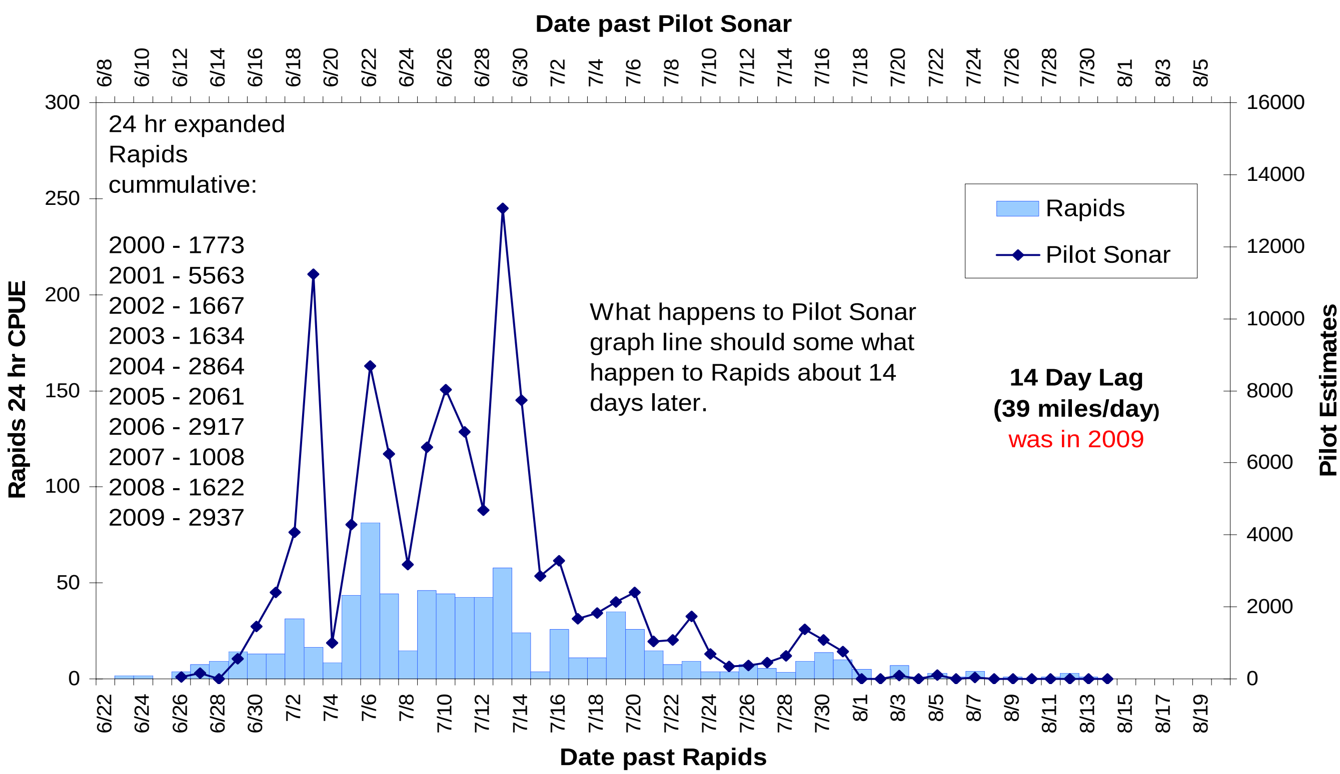


Figure 3

2000 to 2010 Rapids Video, All Sizes of Chinook, Cumulative CPUE and Average Compared (Rapids Research Center)

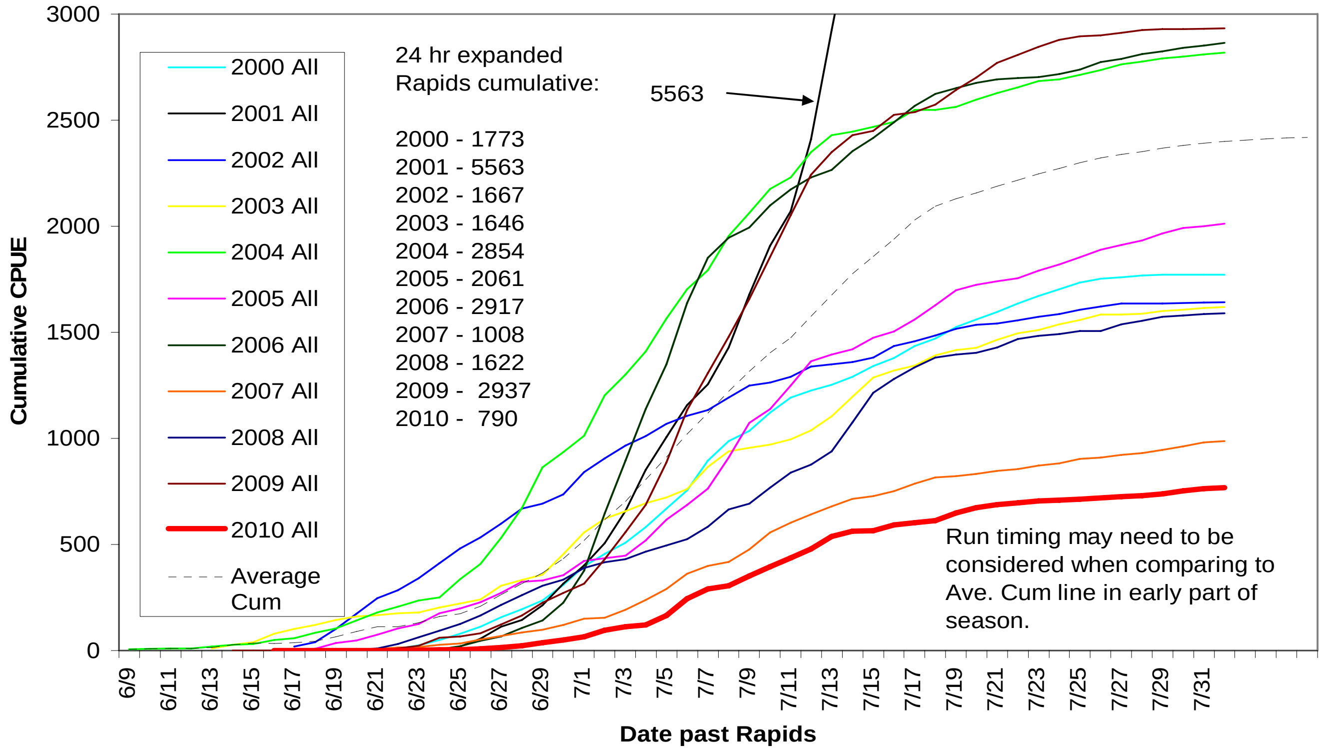
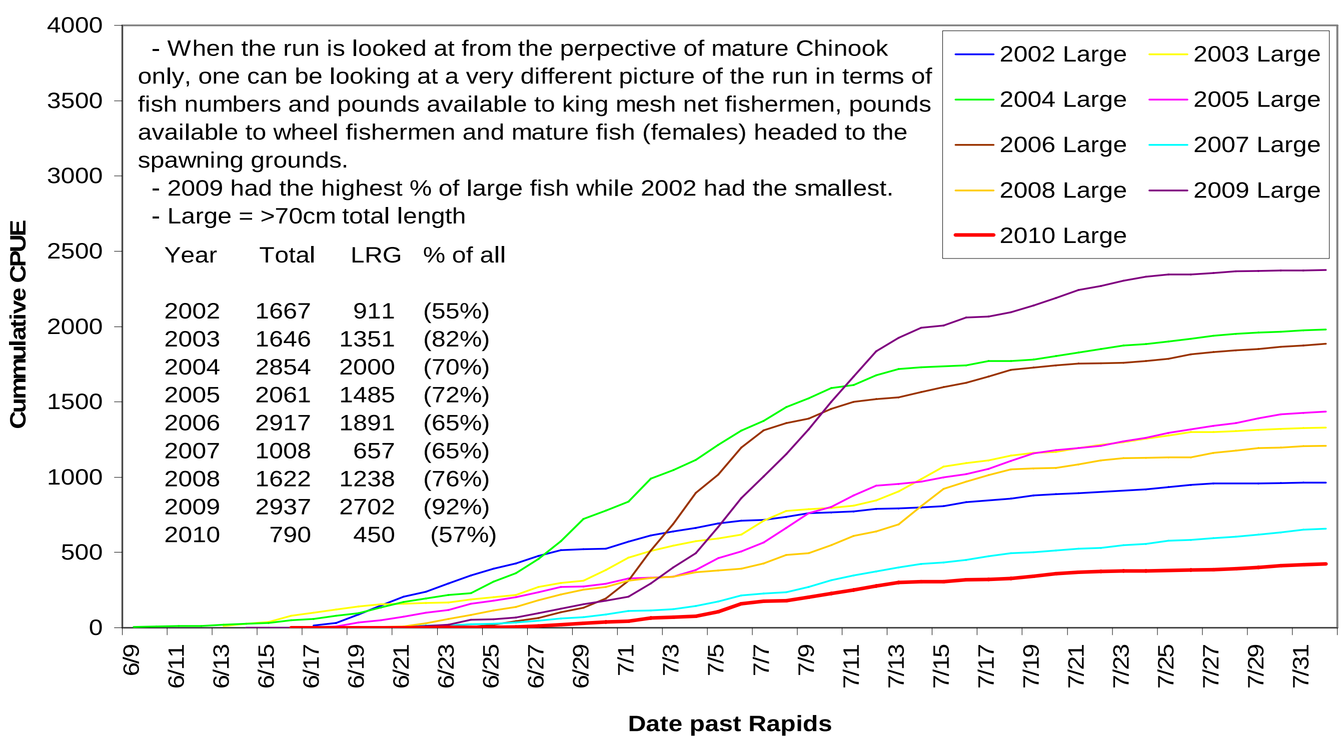


Figure 4

2002 to 2010 Large Chinook Cummulative CPUE
(Rapids Research Center)



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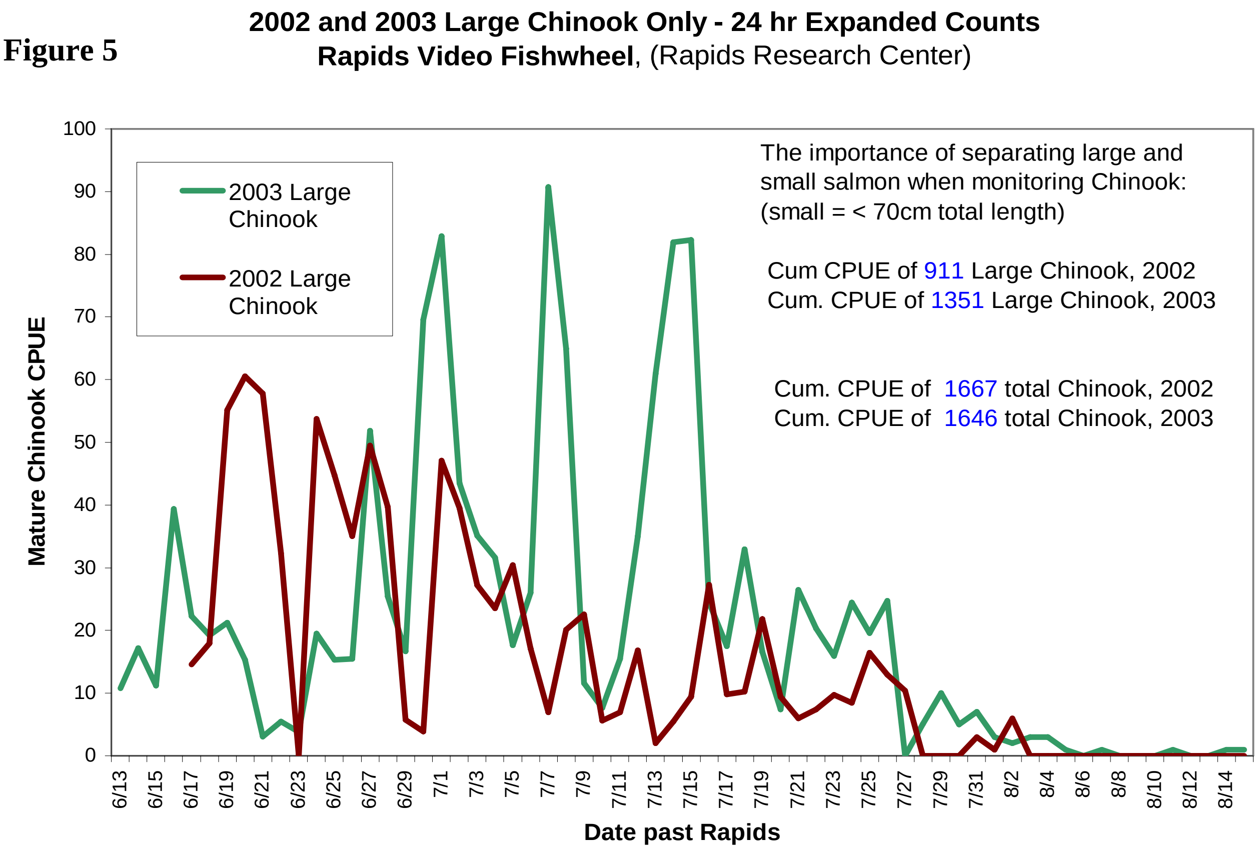

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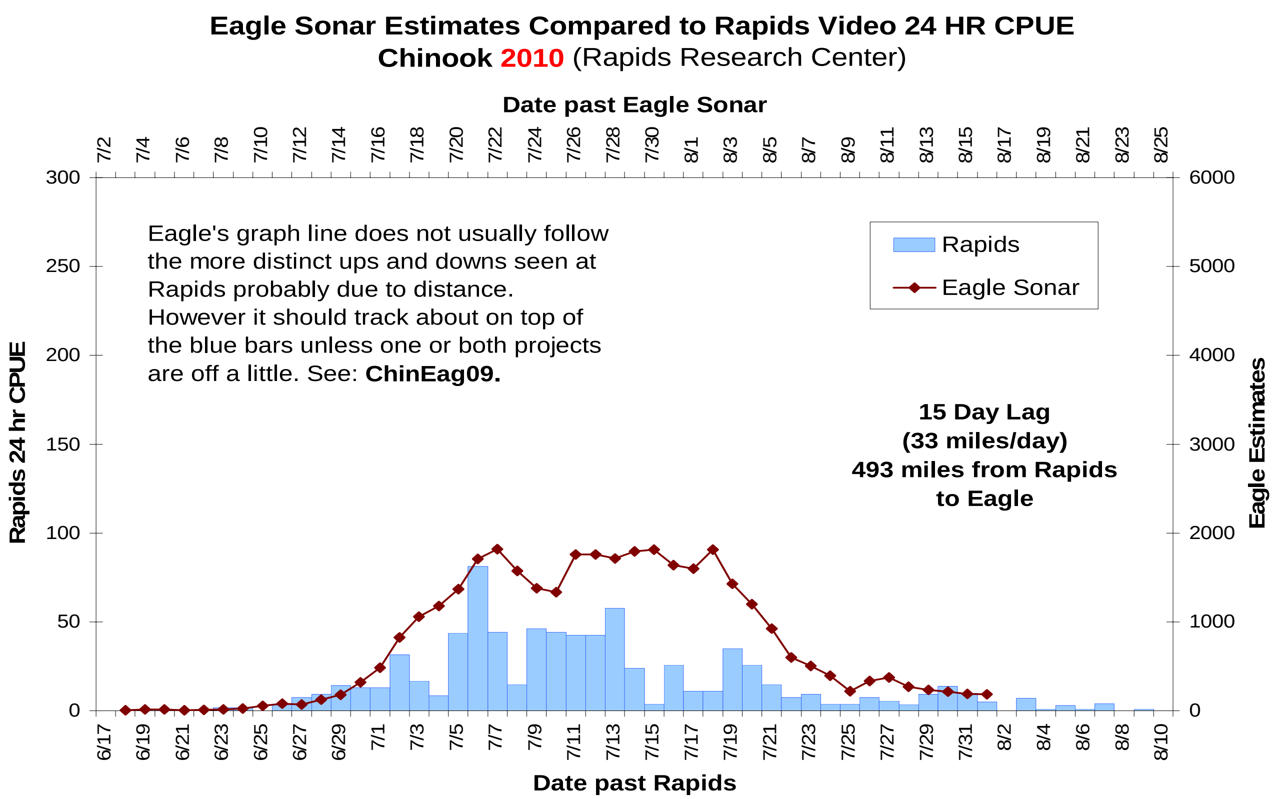

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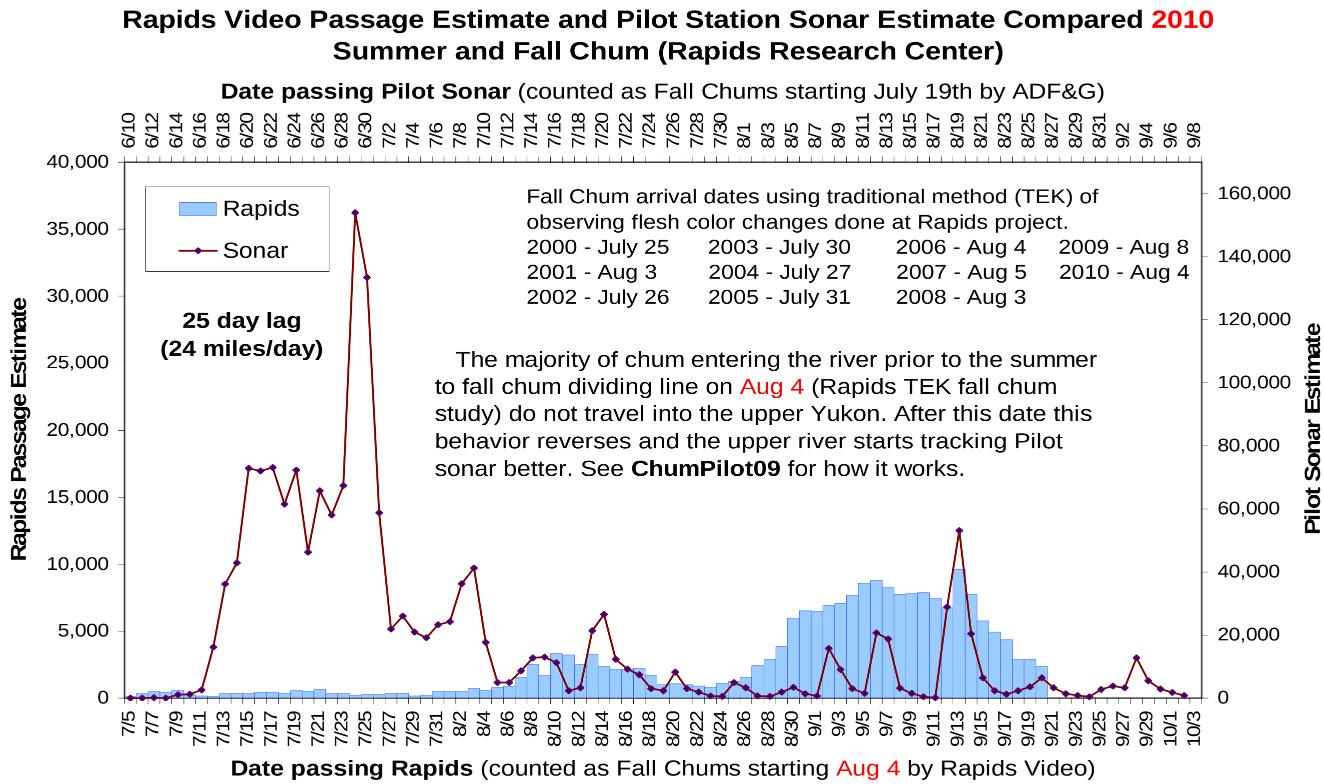

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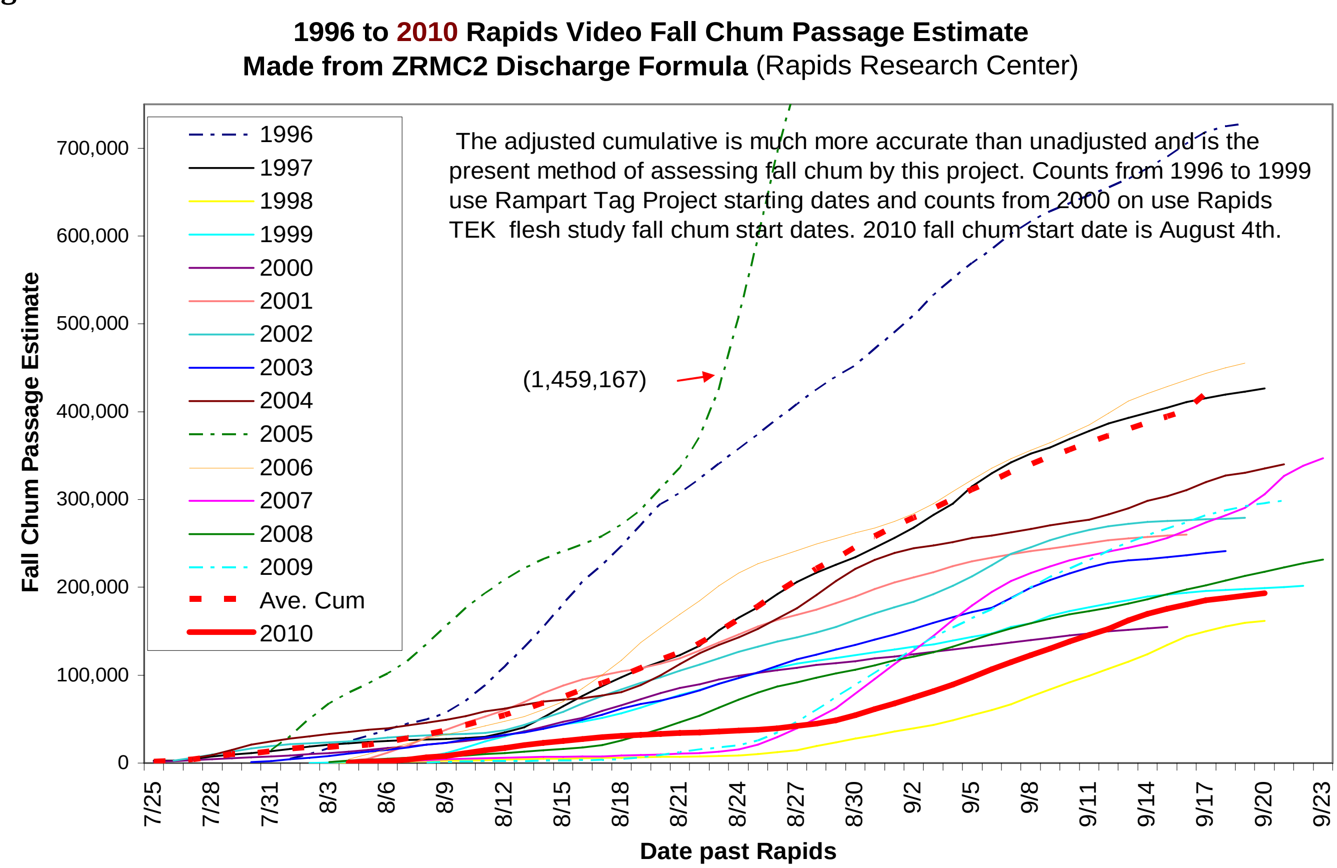


Figure 9

1996 to 2005 Upper Yukon Fall Chum Run Reconstruction Estimate Compared to Rapids Video CPUE, ZRMC2 Passage Estimate and USFWS Rampart Rapids Tagging Estimate
(Rapids Research Center)

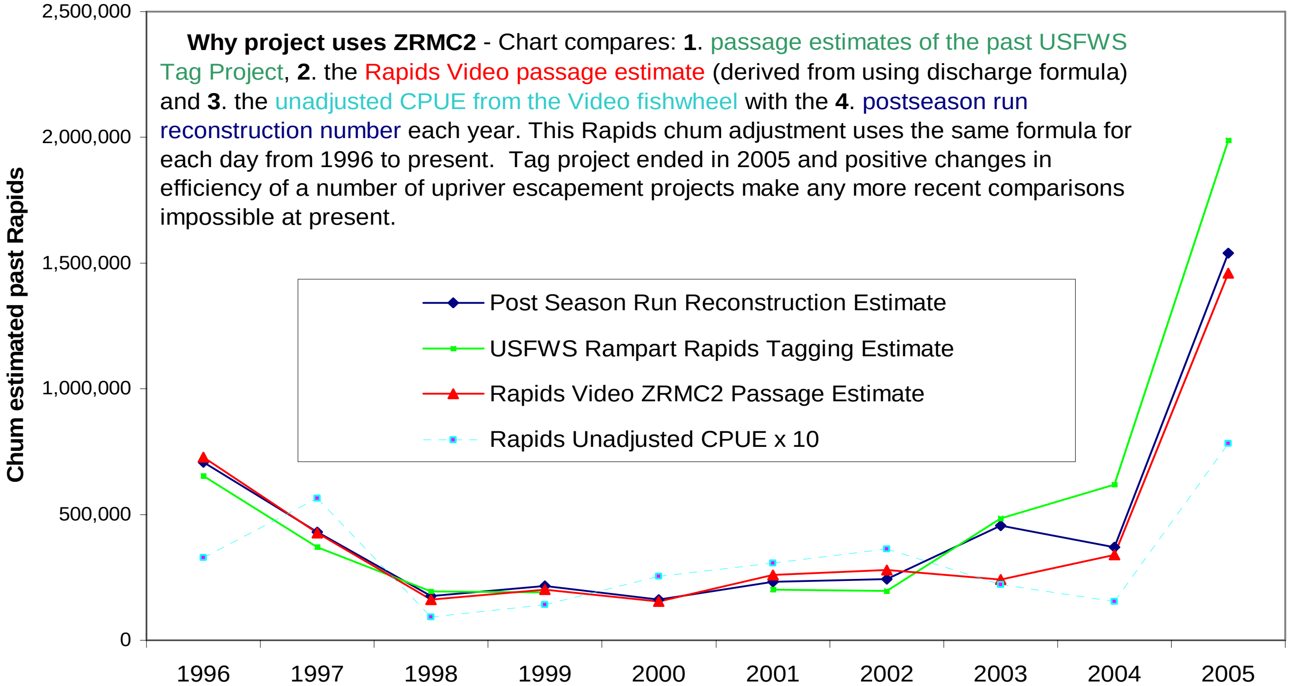
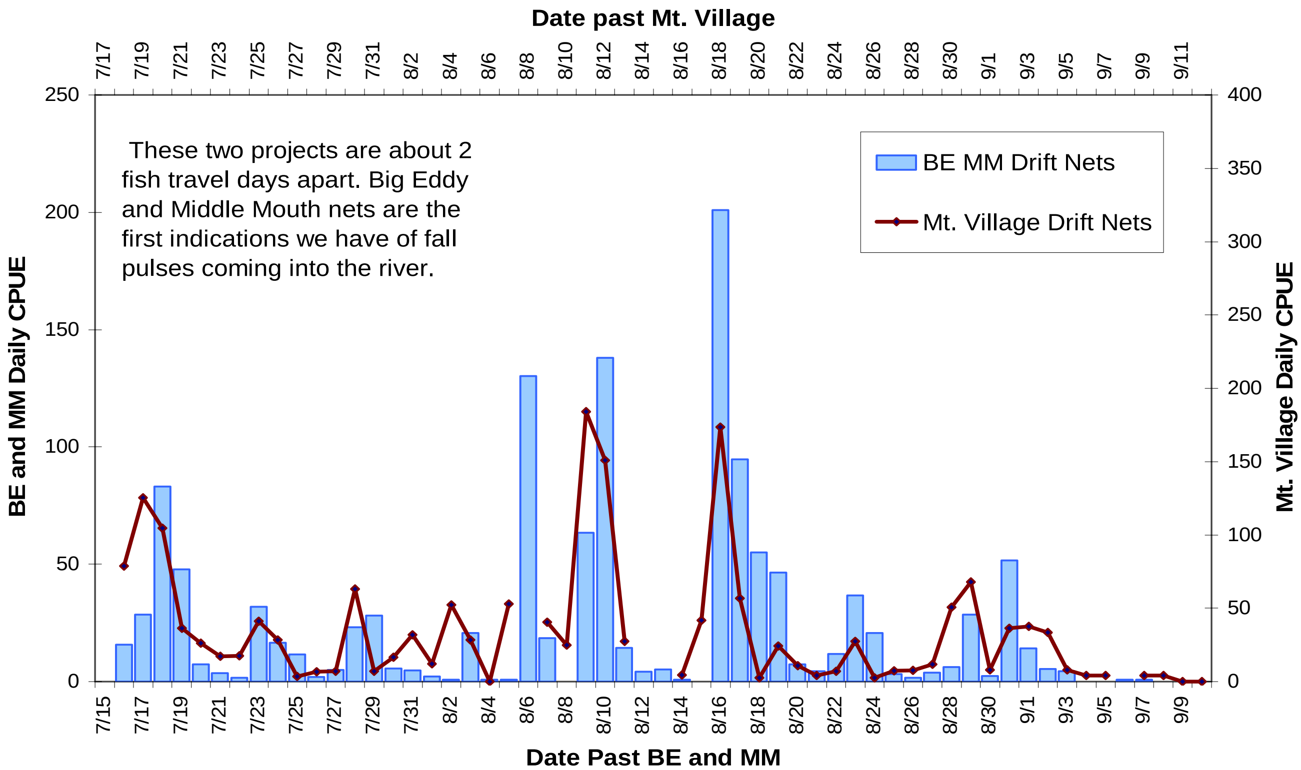


Figure 10

BE and MM Drift Nets Compared to Mt. Village Drift Nets
Fall Chum 2010, Rapids Research Center



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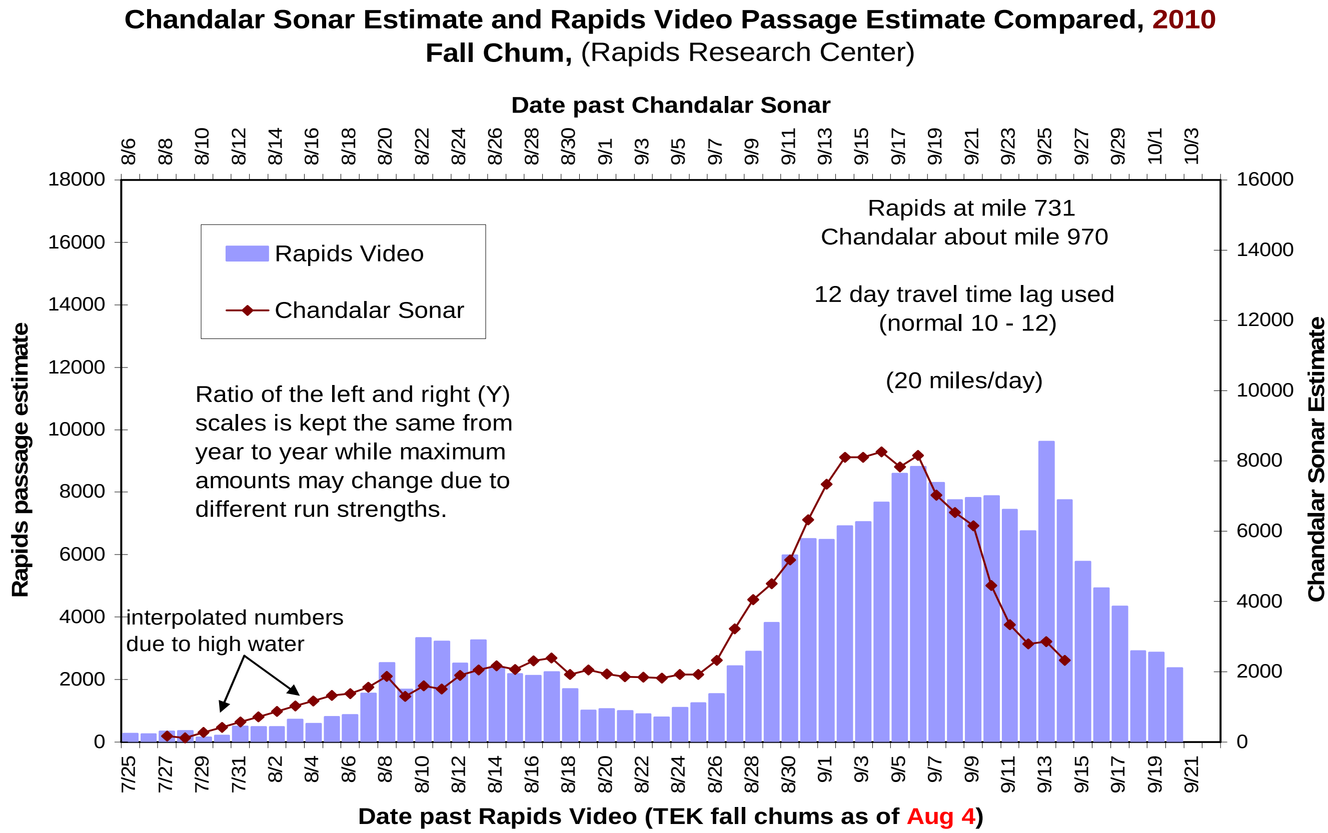

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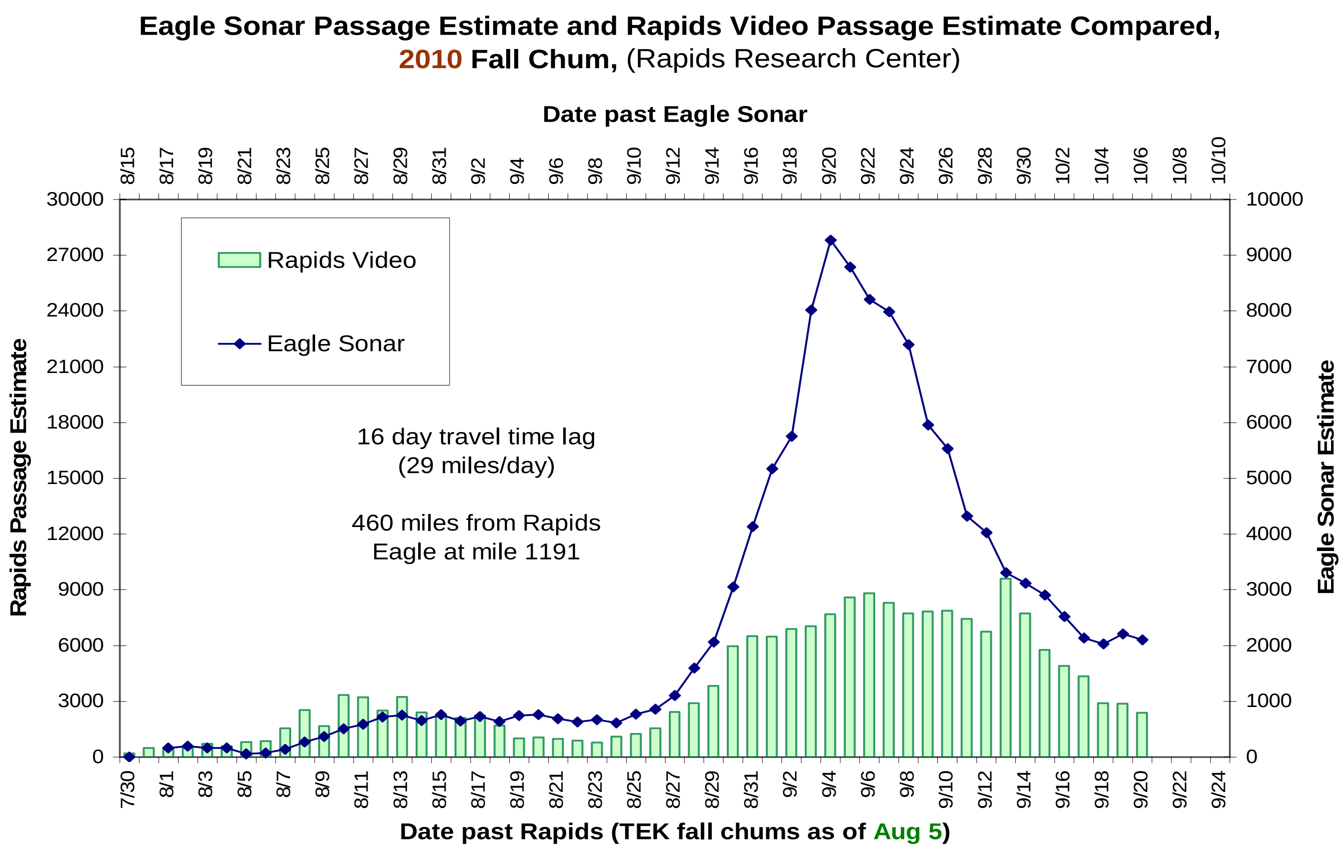
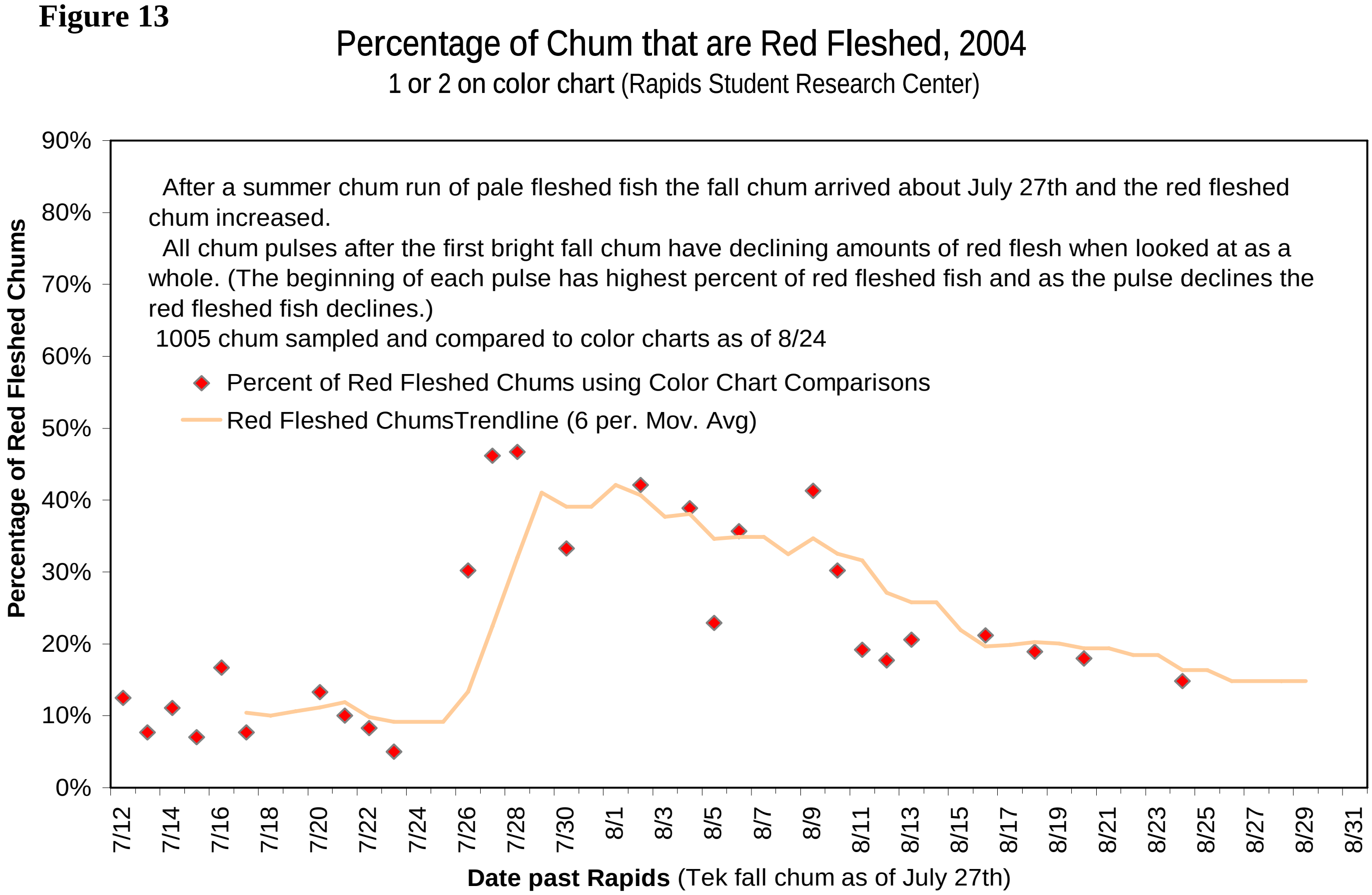


Figure 13



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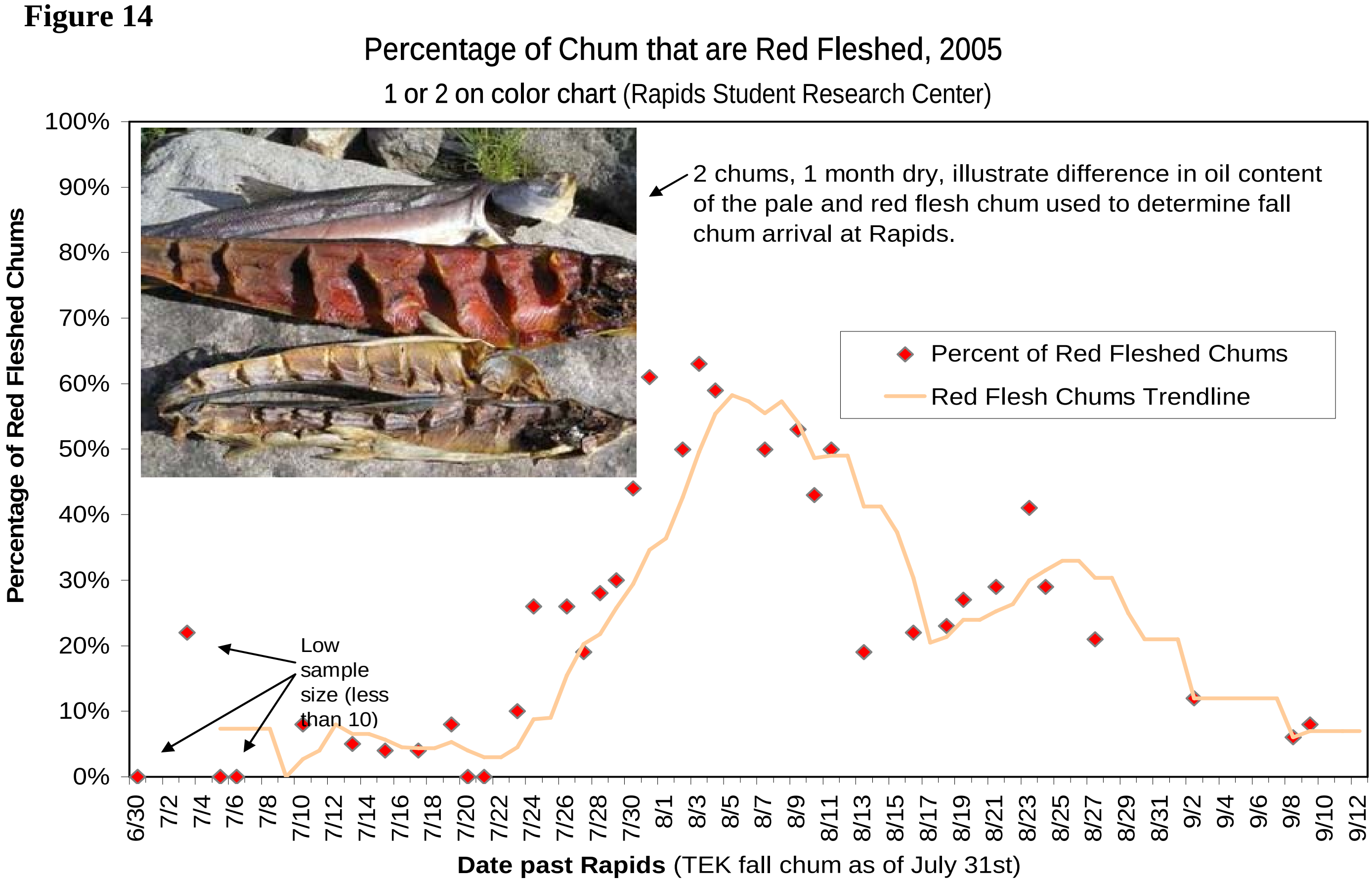

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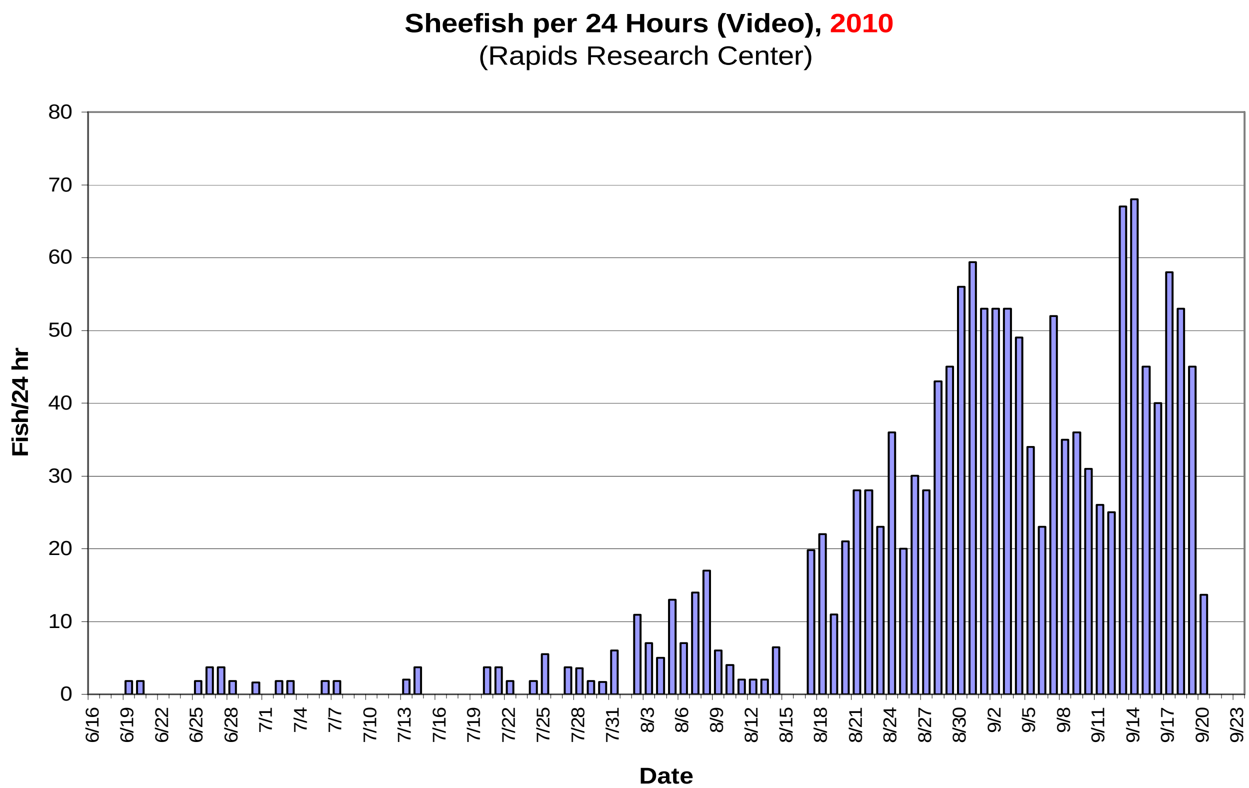

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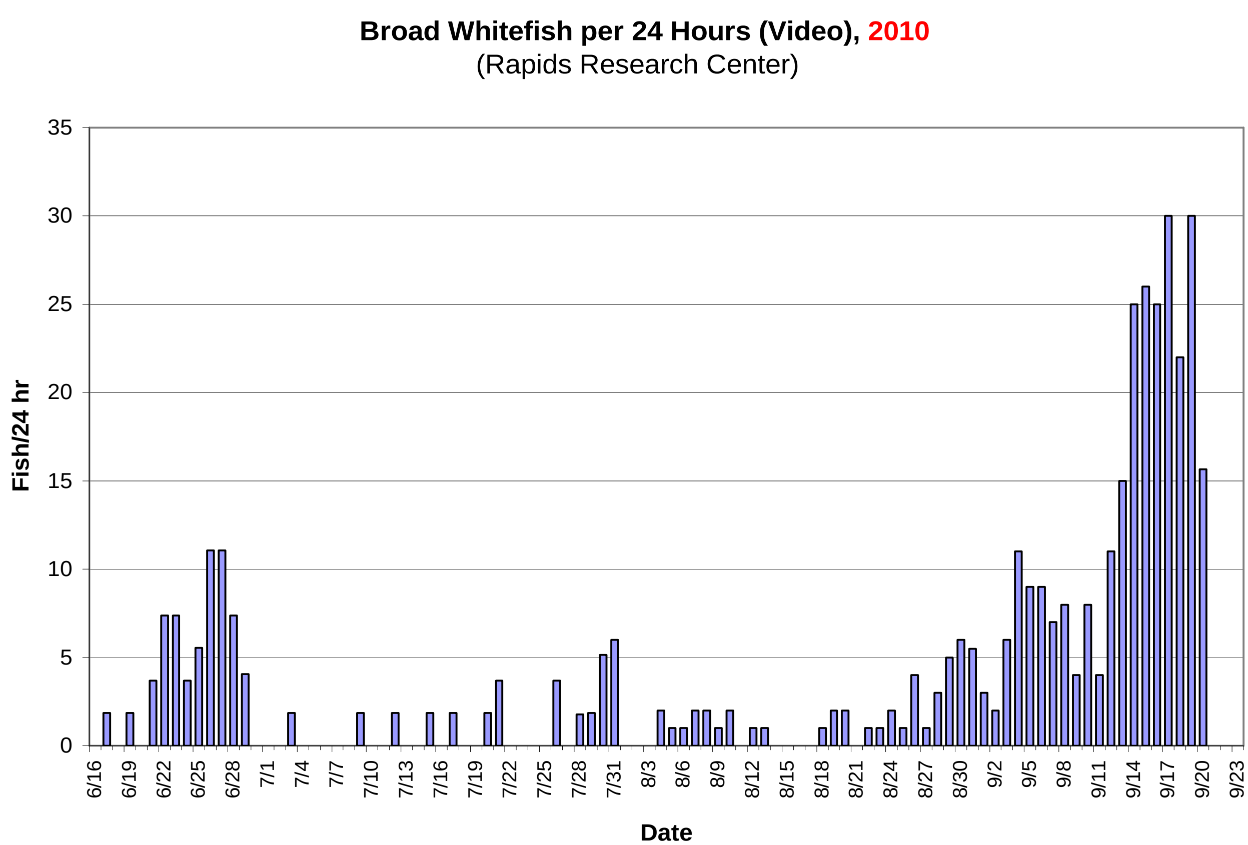

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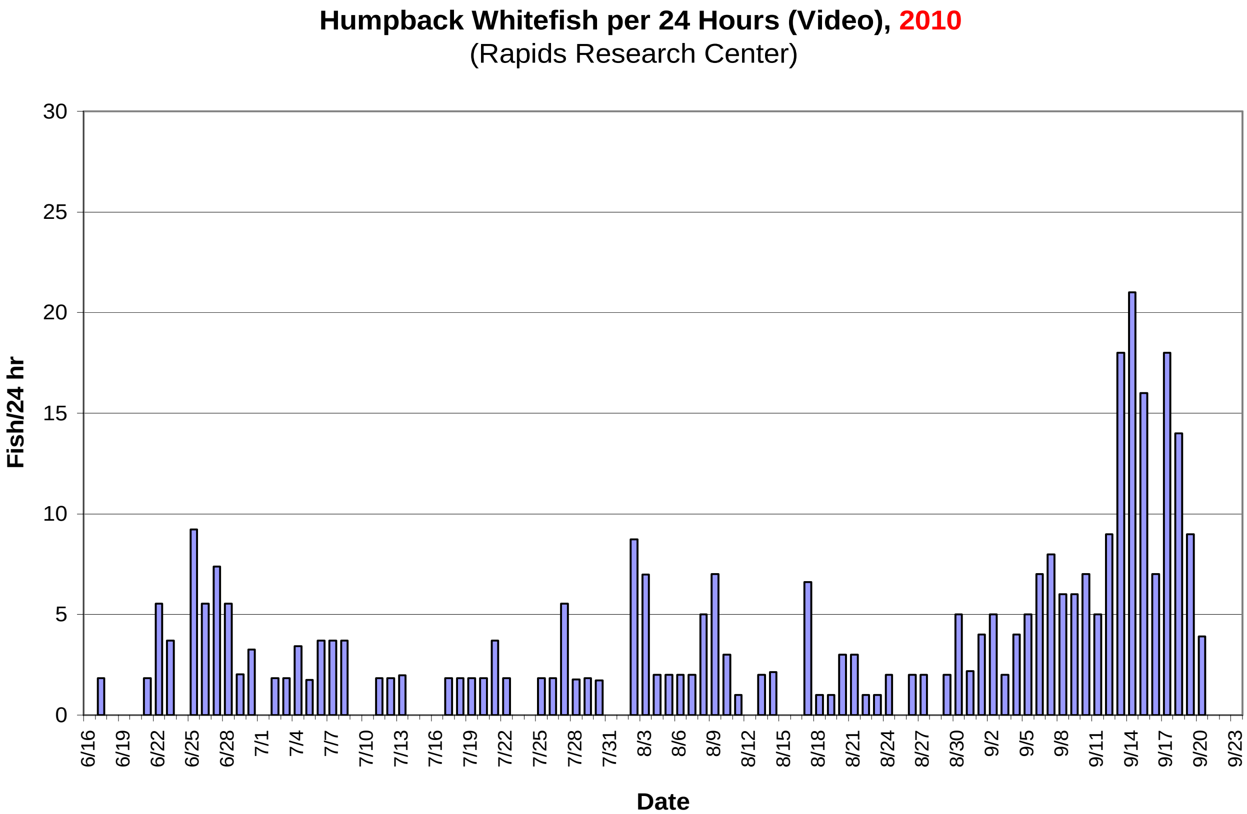

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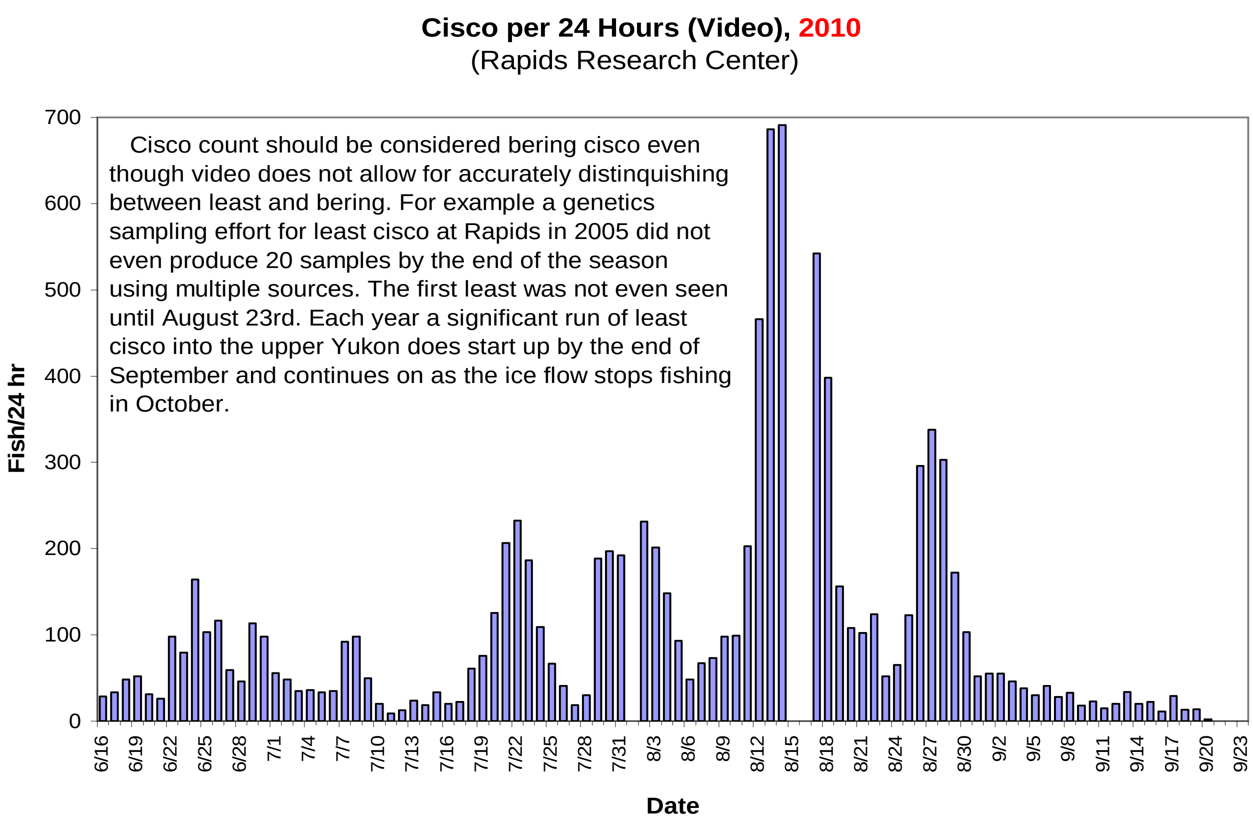
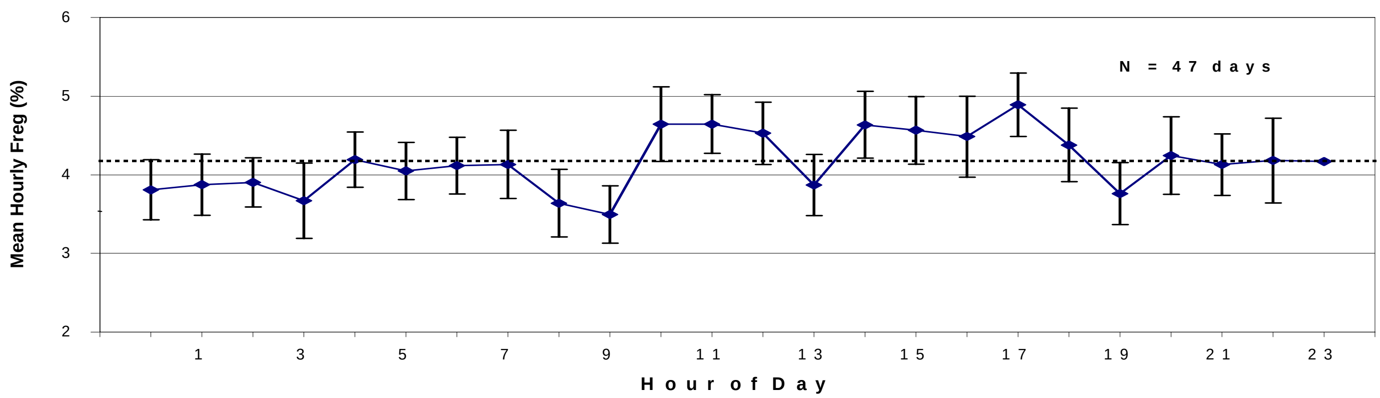


Diel catch patterns of 2003-2005 fall chum (Thanks to Dave Daum, USFWS)

Figure 19.

Mean (± 2SE) hourly frequency of fall chum salmon caught at the Rapids test wheel, Yukon River 2003. Dashed line represents the average hourly catch (4.16%). Data include only days with 24 h of continuous records and a daily capture of over 100 fish.



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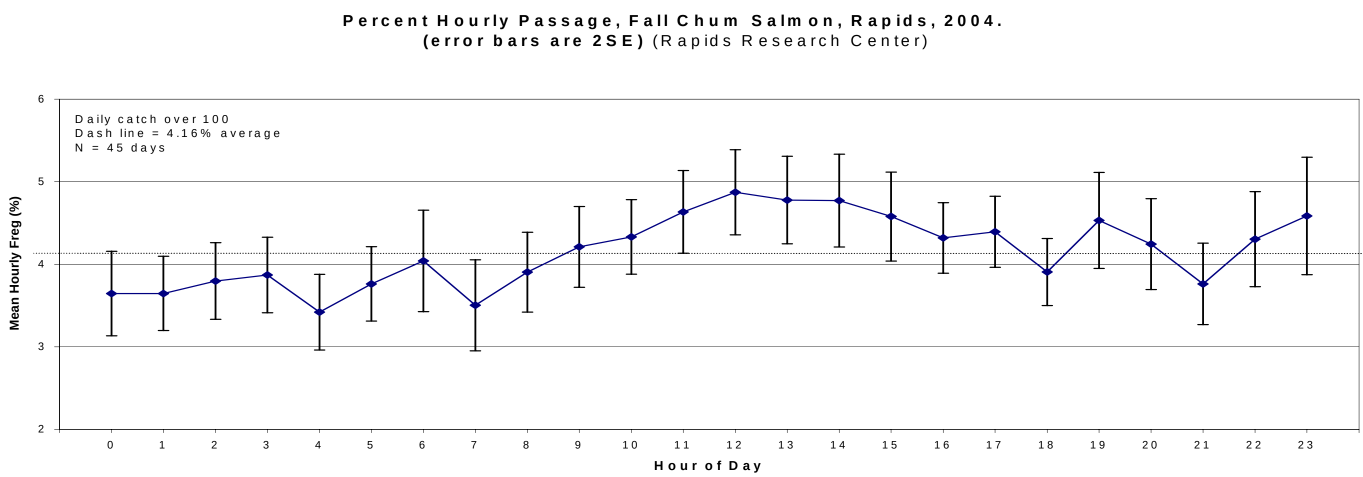

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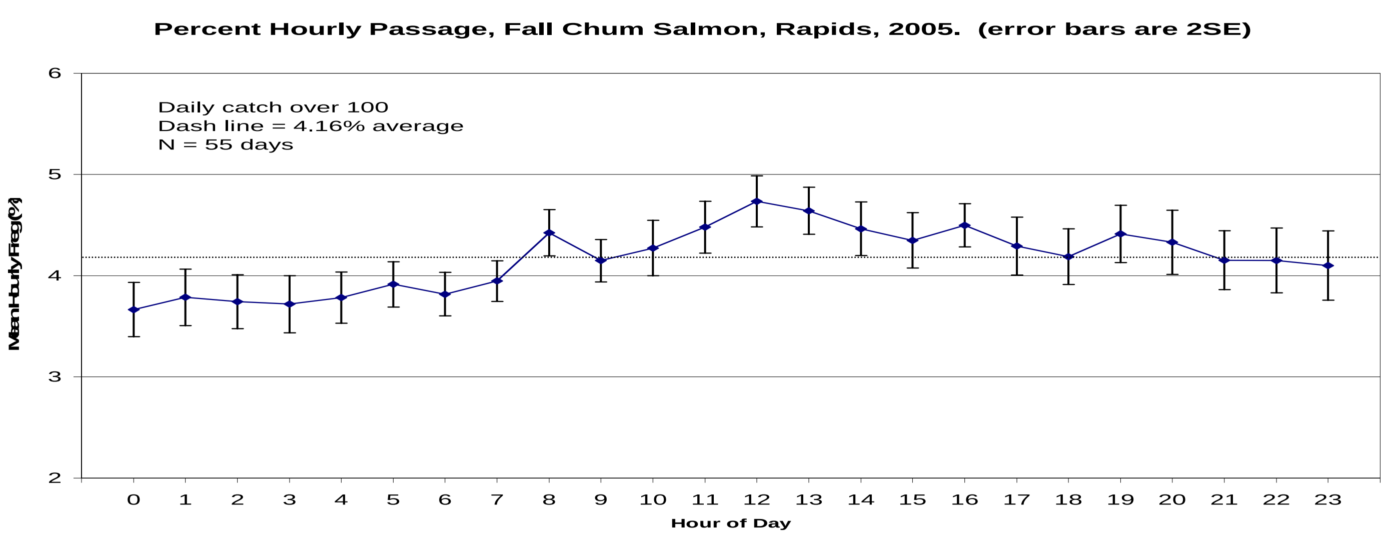

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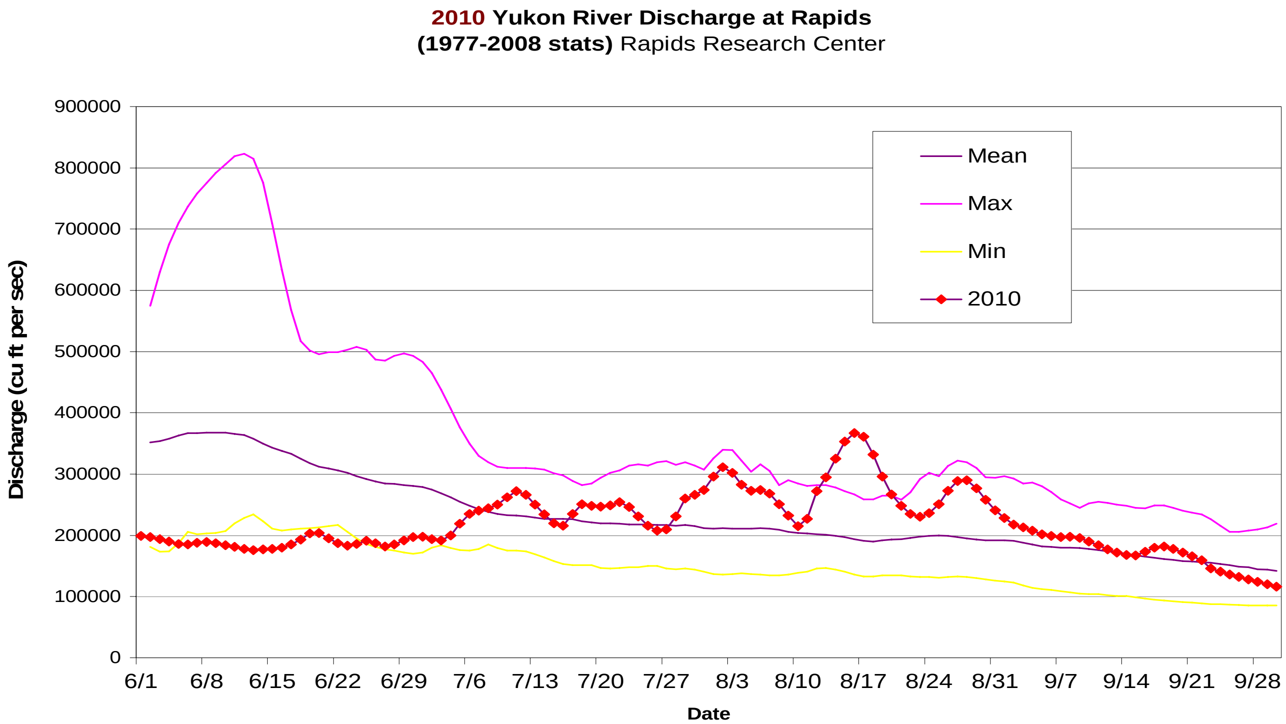

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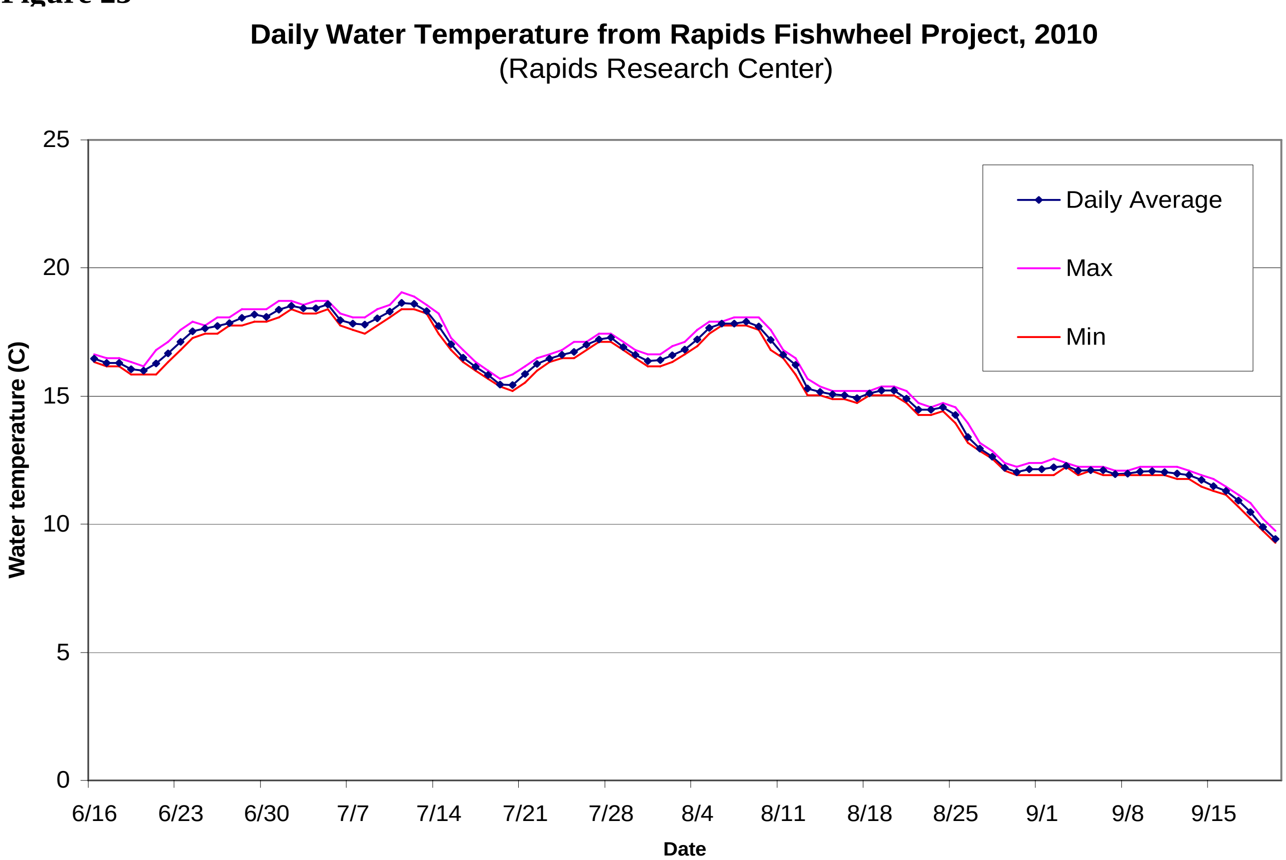

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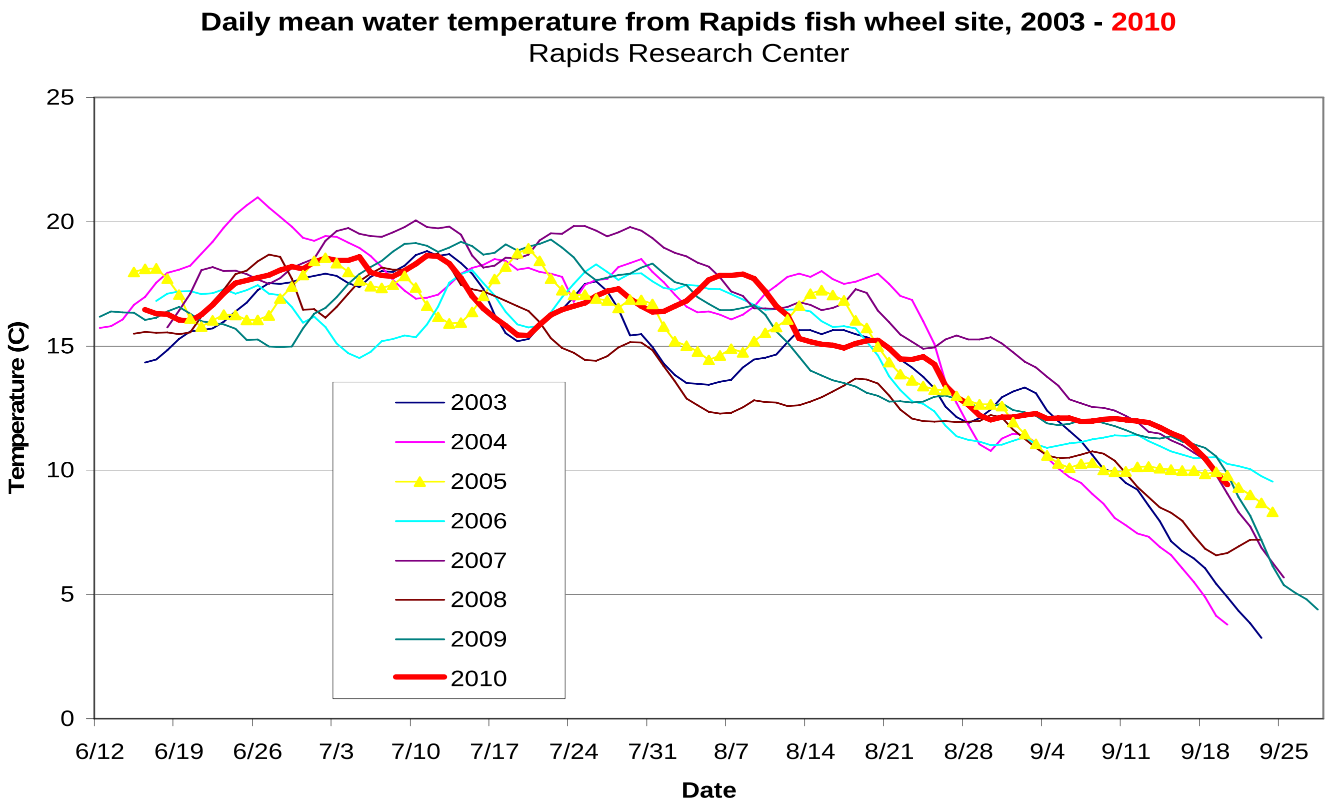

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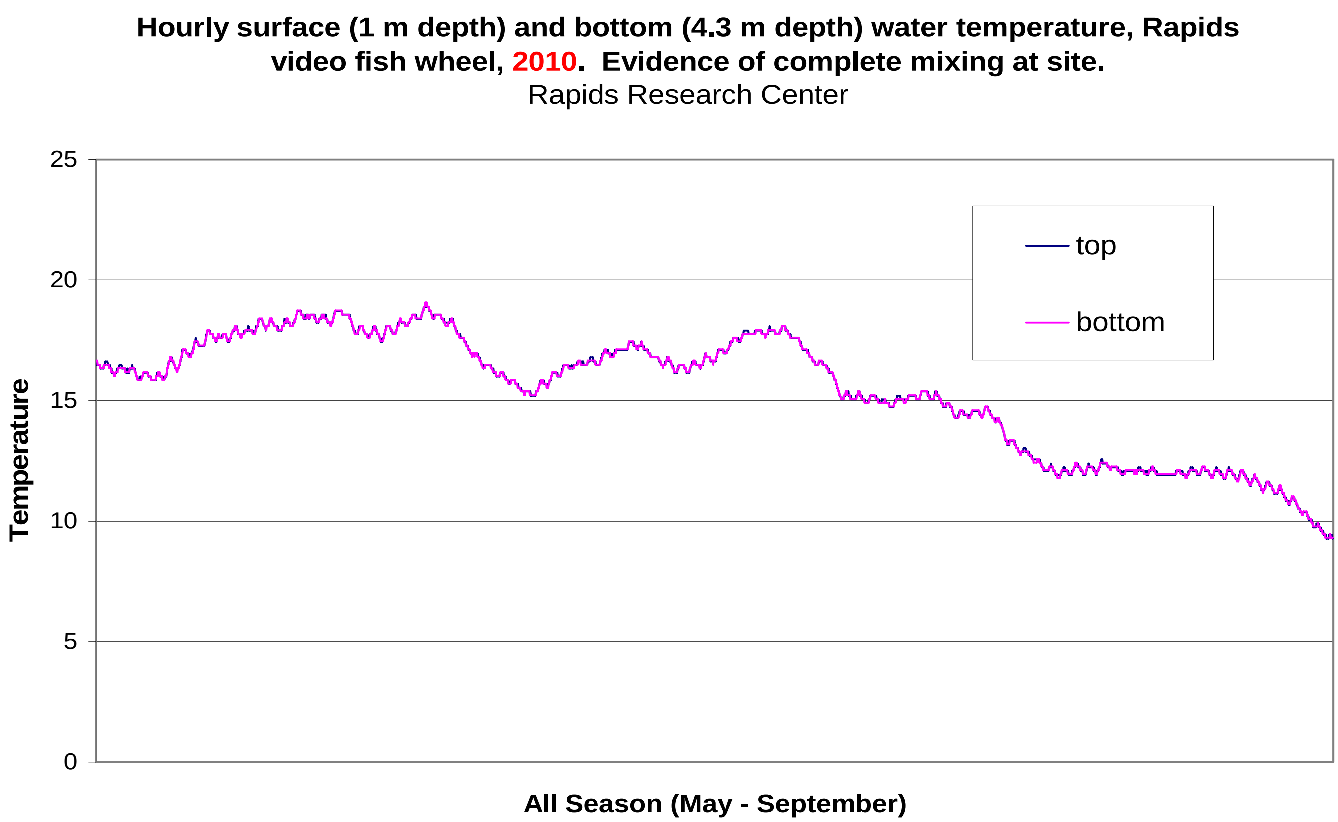

Figure 26

Rapids south bank video fish wheel – 2010

Infrared transmitter / receiver placement (red), and general direction of beams across chute (green).

Infrared triggered LED testing light going on as fish pass sensor in slot mid chute (by sheefish)

Rapids Research new water power system at main camp, 2010

Infrared transmit and receive arrays and control lunchbox

Figure 27

Changing paddle boards to keep wheel rotation slow for fish friendly operation.

Strategic placement of closed cell foam padding reduces injury dramatically to the fish.

Video wheel also used for subsistence during fish openings in 2010.

2 chums, 1 month dry, illustrate difference in oil content of the pale and red flesh chum used to determine fall chum arrival at Rapids.

2010 Video wheel ready to be pulled out by winch at end of season in Rapids area.

Winch used by project to pull wheel out of water at Rapids in 2010

Figure 28

USFWS biologists visit Rapids Video in 2010 to research multiple whitefish species.

King measures and disease sampling for Rapids techs. Here with ADF&G biologists, 2010

Rapids Canyon from above the video project main camp.

Chinook heart Ichthyophonus. In 9% of females and 4% of males in 2010. Lowest in 12 years.

Video Project supports an AYK SSI data collection effort. Rapids techs 2010.

Stan Z. and Dave Daum (USFWS) make adjustments to video chute, 2010

Figure 29 Site map

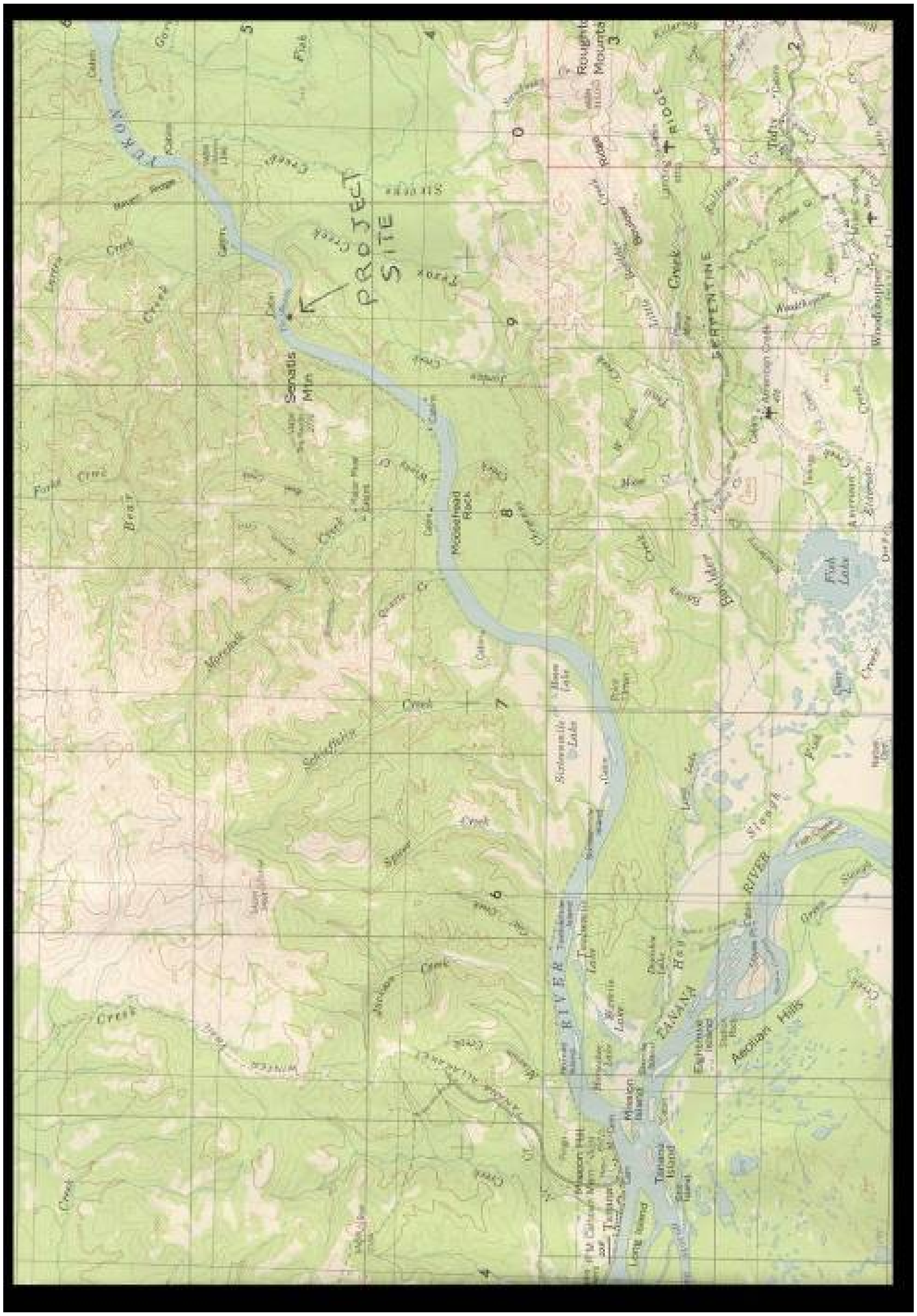

Table 2

		2010 Video Short Summary-Rapids														
Start Day	Counting Date	Start Time	End Time	Run Time (hr)	King Salmon	Percent "Jack"	Chum Salmon	Shee-fish	Broad WF	Hump back	Cisco WF	Water Temp C	F	Comments	King / 24 hr	Chum / 24 hr
Wed	6/16/2010	14:30:00	22:05:20	7.59	0	0.00%	0	0	0	0	9	16.4	61.5	wheel turning and project officially starts	0.00	0.00
Thu	6/17/2010	8:00:00	21:00:00	13.00	0	0.00%	0	0	1	1	18	16	60.8	small cisco run, 3 other wheels by shore here	0.00	0.00
Fri	6/18/2010	8:00:00	21:00:00	13.00	0	0.00%	0	0	0	0	26	16.2	61.2	water up, but still very low, Yukon 800 tomorrow	0.00	0.00
Sat	6/19/2010	8:00:00	21:00:00	13.00	0	0.00%	0	1	1	0	28	16.1	61	Water cresting, large sheefish and few broads, cisco up	0.00	0.00
Sun	6/20/2010	8:00:00	21:00:00	13.00	0	0.00%	0	1	0	0	17	15.9	60.6	Drift slowing down, cisco down, no king nets in.	0.00	0.00
Mon	6/21/2010	8:00:00	21:00:00	13.00	0	0.00%	0	0	2	1	14	16.6	61.9	water down, cisco down, Dave D. here	0.00	0.00
Tue	6/22/2010	8:00:00	21:00:00	13.00	0	0.00%	0	0	4	3	53	16.3	61.3	cisco shot up, Russ here, LJ first Rapids king	0.00	0.00
Wed	6/23/2010	8:00:00	21:00:00	13.00	1	0.00%	0	0	4	2	43	16.9	62.4	Ist king in video wheel, cisco steady	1.85	0.00
Thu	6/24/2010	8:00:00	21:00:00	13.00	1	0.00%	0	0	2	0	89	17.5	63.5	Cisco way up, King few but all gear getting some now.	1.85	0.00
Fri	6/25/2010	8:00:00	21:00:00	13.00	0	0.00%	0	1	3	5	56	17.6	63.7	King still slow in all gear, nets and wheels, 0 to 2/day	0.00	0.00
Sat	6/26/2010	8:00:00	21:00:00	13.00	2	50.00%	0	2	6	3	63	17.6	63.7	King still slow in all gear, nets and wheels, 1 to 3/day	3.69	0.00
Sun	6/27/2010	8:00:00	21:00:00	13.00	4	0.00%	0	2	6	4	32	17.8	64.1	King increasing Tanana and Rapids - better size	7.38	0.00
Mon	6/28/2010	8:00:00	21:00:00	13.00	5	20.00%	0	1	4	3	25	18.3	64.9	steady as king goes, cisco down a bit lately,	9.23	0.00
Tue	6/29/2010	10:20:00	22:11:26	11.86	7	28.57%	0	0	2	1	56	18	64.4	log stopped wheel, king increasing late in day in all gear	14.17	0.00
Wed	6/30/2010	9:00:00	23:42:24	14.71	8	37.50%	0	1	0	2	60	17.9	64.2	Another log in morning delayed start, cc3x as usual	13.06	0.00
Thu	7/1/2010	8:00:00	21:00:00	13.00	7	57.14%	0	0	0	0	30	18.2	64.8	all fishers report lower catches, net and wheel	12.92	0.00
Fri	7/2/2010	8:00:00	21:00:00	13.00	17	35.29%	0	1	0	1	26	18.5	65.3	king increase, but slow fishing at 6 pm start for fishers	31.38	0.00
Sat	7/3/2010	7:30:00	20:30:00	13.00	9	55.56%	0	1	1	1	19	18.2	64.9	some gear did good at night -slower day - video down	16.62	0.00
Sun	7/4/2010	7:30:00	21:30:00	14.00	5	40.00%	3	0	0	2	21	18.3	64.9	first chum but a report of some in last 4 days	8.57	5.14
Mon	7/5/2010	7:30:00	21:15:00	13.75	25	32.00%	9	0	0	1	19	18.6	65.5	chum increase and 2nd pulse of king shows	43.64	15.71
Tue	7/6/2010	8:30:00	21:30:00	13.00	44	34.09%	24	1	0	2	19	17.8	64	all fishers increased king catch, drift shut down some	81.23	44.31
Wed	7/7/2010	8:30:00	21:30:00	13.00	24	62.50%	38	1	0	2	50	17.8	63.9	chum and cisco increase, pulse 2 ending.	44.31	70.15
Thu	7/8/2010	8:30:00	21:30:00	13.00	8	75.00%	36	0	0	2	53	17.8	64	all gear way down on king but chum increasing	14.77	66.46
Fri	7/9/2010	8:30:00	21:30:00	13.00	25	52.00%	47	0	1	0	27	17.8	64	king up but all gear shows not as strong as pulse 2 yet	46.15	86.77
Sat	7/10/2010	8:30:00	21:30:00	13.00	24	45.83%	22	0	0	0	11	18.2	64.8	less chum in all wheels. Drift worst day, water steady	44.31	40.62
Sun	7/11/2010	8:30:00	21:30:00	13.00	23	43.48%	17	0	0	1	5	18.6	65.5	visible Ich 4.6% weight 11.1 lbs % of fem. 12.8%	42.46	31.38
Mon	7/12/2010	8:30:00	21:30:00	13.00	23	39.13%	14	0	1	1	7	18.6	65.5	Closed fishing till tomorrow, king steady	42.46	25.85
Tue	7/13/2010	10:58:06	23:01:20	12.05	29	58.62%	25	1	0	1	12	18.3	64.8	another log stopped wheel - late start video	57.74	49.78
Wed	7/14/2010	8:30:00	21:30:00	13.00	13	76.92%	26	2	0	0	10	17.7	63.9	King down today, pulse 4 peaked last night,	24.00	48.00
Thu	7/15/2010	8:30:00	21:30:00	13.00	2	100.00%	21	0	1	0	18	16.9	62.6	all gear down and small king predominate.	3.69	38.77
Fri	7/16/2010	8:30:00	21:30:00	13.00	14	50.00%	26	0	0	0	11	16.5	61.7	little king increase - small size still	25.85	48.00
Sat	7/17/2010	8:30:00	21:30:00	13.00	6	66.67%	33	0	1	1	12	16.1	61	water up but no drift yet.	11.08	60.92
Sun	7/18/2010	8:30:00	21:30:00	13.00	6	66.67%	31	0	0	1	33	15.9	60.6	chum at 25% red flesh today ? but no chum increase?	11.08	57.23
Mon	7/19/2010	8:30:00	21:30:00	13.00	19	57.89%	47	0	0	1	41	15.4	59.7	little king pulse, chum up slightly	35.08	86.77
Tue	7/20/2010	8:30:00	21:30:00	13.00	14	28.57%	44	2	1	1	68	15.5	59.9	bigger king but poor looking, cisco run up good	25.85	81.23
Wed	7/21/2010	8:00:00	21:00:00	13.00	8	37.50%	55	2	2	2	112	16.4	61.5	couple of big nice looing king, cisco really increasing	14.77	101.54
Thu	7/22/2010	8:30:00	21:30:00	13.00	4	25.00%	28	1	0	1	126	61	61	more cisco, ICH increasing as normal	7.38	51.69
Fri	7/23/2010	8:30:00	21:30:00	13.00	5	80.00%	29	0	0	0	101	17	62.6	2 wheels pulled, only 1 fishing and 3 nets, quiet,	9.23	53.54
Sat	7/24/2010	8:30:00	21:30:00	13.00	2	50.00%	13	1	0	0	59	16.1	#REF!	summer chum way down, cisco also	3.69	24.00
Sun	7/25/2010	8:30:00	21:30:00	13.00	2	50.00%	16	3	0	1	36	17.3	63.7	some nice big sheefish starting	3.69	29.54
Mon	7/26/2010	8:30:00	21:30:00	13.00	4	50.00%	14	0	2	1	22	17.5	63.5	not many fish today, water stable	7.38	25.85
Tue	7/27/2010	8:30:00	21:30:00	13.00	3	33.33%	20	2	0	3	10	17.7	63.9	not many fish today, water up	5.54	36.92
Wed	7/28/2010	8:30:00	23:30:00	13.48	2	0.00%	26	2	1	1	17	17.9	64.2	drift coming, still summer chum, flesh at 15% red	3.56	46.29
Thu	7/29/2010	8:30:00	21:30:00	13.00	5	0.00%	14	1	1	1	102	17.5	63.5	water up drift not bad. Cisco way up, last king bump	9.23	25.85
Fri	7/30/2010	7:30:00	21:30:00	14.00	8	12.50%	21	1	3	1	115	17.4	63.3	more drift, last king bump big sized fish	13.71	36.00
Sat	7/31/2010	8:30:00	20:30:00	12.00	5	20.00%	47	3	3	0	96	16.9	62.4	more drift, shut off wheel early, tomorrow??	10.00	94.00
Sun	8/1/2010	chum and k	0:00:00	0.00	0	0.00%	0	0	0	0	0	17	62.6	more drift, did not run wheel but get ready for fall	5.00	103.82
Mon	8/2/2010	11:46:15	22:45:11	10.98	0	0.00%	52	5	0	4	106	17.3	63.7	Water crested, ran wheel but stayed by it lots	0.00	113.64
Tue	8/3/2010	8:30:00	22:13:41	13.73	4	0.00%	92	4	0	4	115	17.3	63.1	drift clearing lots, chum up - check flesh tomorrow	6.99	160.84

Table 3

		2010 Video Short Summary-Rapids														
Start	Counting	Start	End	Run Time	King	Percent	Chum	Shee-	Broad	Hump	Cisco	Water Temp			King	Chum
Day	Date	Time	Time	(hr)	Salmon	"Jack"	Salmon	fish	WF	back	WF	C	F	Comments	/ 24 hr	/ 24 hr
Wed	8/4/2010	0:00:00	23:59:59	24.00	1	0.00%	118	5	2	2	148	18.2	64.8	Official Fall chum day, 75% red fleshed chum	1.00	118.00
Thu	8/5/2010	0:00:00	23:59:59	24.00	3	33.33%	152	13	1	2	93	18.2	64.8	72% red fleshed chum,	3.00	152.00
Fri	8/6/2010	0:00:00	23:59:59	24.00	1	0.00%	163	7	1	2	48	17.8	64	big upwind and waves, chum steady, bad cut weather	1.00	163.00
Sat	8/7/2010	0:00:00	23:59:59	24.00	4	25.00%	282	14	2	2	67	18.6	65.5	chum increasing, nice fish	4.00	282.00
Sun	8/8/2010	0:00:00	23:59:59	24.00	0	0.00%	404	17	2	5	73	18.5	65.3	chum up, all fishers cutting good chum for days now.	0.00	404.00
Mon	8/9/2010	0:00:00	23:59:59	24.00	1	0.00%	227	6	1	7	98	18.5	65.3	chum down, rainy, no fishing / bad drying	1.00	227.00
Tue	8/10/2010	0:00:00	23:59:59	24.00	0	0.00%	380	4	2	3	99	17.9	64.2	chum up, Water rising	0.00	380.00
Wed	8/11/2010	0:00:00	23:59:59	24.00	1	0.00%	415	2	0	1	203	17.3	63.1	cisco doubled and chum still up good	1.00	415.00
Thu	8/12/2010	0:00:00	23:59:59	24.00	3	0.00%	469	2	1	0	466	17	62.6	cisco doubled again to high of 466	3.00	469.01
Fri	8/13/2010	0:00:00	23:59:59	24.00	1	100.00%	702	2	1	2	686	15.8	60.4	cisco record of 686, water got real dirty (secchi - 6cm)	1.00	702.01
Sat	8/14/2010	0:00:00	11:08:54	11.15	0	0.00%	283	3	0	1	321	15.9	60.6	cisco record of 691, chum little down	0.00	609.24
Sun	8/15/2010	#REF!	chum counts	0.00	0	0.00%	0	0	0	0	0	15.9	60.6	drift shut video wheel down all day - no count at all	0.00	629.85
Mon	8/16/2010	#REF!	chum counts	0.00	0	0.00%	0	0	0	0	0	16.1	61	drift has a heavy run early in day - no count at all	0.00	650.46
Tue	8/17/2010	16:34:00	23:59:59	7.26	0	0.00%	203	6	0	2	164	15.7	60.3	water down,	0.00	671.07
Wed	8/18/2010	0:00:00	23:59:59	24.00	0	0.00%	447	22	1	1	398	15.9	60.4	middle wheel going also, water dropping rapidly	0.00	447.01
Thu	8/19/2010	0:00:00	23:59:59	24.00	0	0.00%	218	11	2	1	156	15.9	60.4	chum dropped off - RM + video wheels	0.00	218.00
Fri	8/20/2010	0:00:00	23:59:59	24.00	0	0.00%	189	21	2	3	108	15.7	60.3	first coho, sheefish still coming in good	0.00	189.00
Sat	8/21/2010	0:00:00	23:59:59	24.00	1	0.00%	154	28	0	3	102	15.4	59.7	Sheefish up, water down still,	1.00	154.00
Sun	8/22/2010	0:00:00	23:59:59	24.00	0	0.00%	124	28	1	1	124	15.2	59.4	water still down more, more spawn colors on chum	0.00	124.00
Mon	8/23/2010	0:00:00	23:59:59	24.00	1	0.00%	106	23	1	1	52	15	59	water steady, chum down more and cisco also	1.00	106.00
Tue	8/24/2010	0:00:00	23:59:59	24.00	0	0.00%	154	36	2	2	65	15	59	water up little, chum up - pulse 1 ??,	0.00	154.00
Wed	8/25/2010	0:00:00	23:59:59	24.00	0	0.00%	199	20	1	0	123	14.6	58.3	water up more, little drift now. Chum up slightly	0.00	199.00
Thu	8/26/2010	0:00:00	23:59:59	24.00	0	0.00%	289	30	0	2	296	13.9	57	water up more, little drift now. Chum up good bit	0.00	289.00
Fri	8/27/2010	0:00:00	23:59:59	24.00	0	0.00%	504	28	1	2	338	13.5	56.3	water cresting, little drift now. Chum up good bit	0.00	504.01
Sat	8/28/2010	0:00:00	23:59:59	24.00	0	0.00%	605	43	3	0	303	13.5	56.3	cc only 2x video - cause of high water!, chum up	0.00	605.01
Sun	8/29/2010	0:00:00	23:59:59	24.00	0	0.00%	737	45	5	2	172	12.7	54.9	chum up and rising, fall water temp drop.	0.00	737.01
Mon	8/30/2010	0:00:00	23:59:59	24.00	1	0.00%	1008	56	6	5	103	12.7	54.9	chum up and nice fish, few more broads and humpies	1.00	1008.01
Tue	8/31/2010	0:00:00	23:59:59	21.83	0	0.00%	871	54	5	2	47	13	55.4	repaired basket chute, video chute and both webbing	0.00	957.58
Wed	9/1/2010	0:00:00	23:59:59	24.00	0	0.00%	846	53	3	4	55	12.7	54.9	pulse 1 cresting??, cisco down, Virgil and Greg	0.00	846.01
Thu	9/2/2010	0:00:00	23:59:59	24.00	0	0.00%	814	53	2	5	55	13.1	55.6	chum still steady pretty much, Mike and Sky and Virgil	0.00	814.01
Fri	9/3/2010	0:00:00	23:59:59	24.00	0	0.00%	786	53	6	2	46	12.9	55.2	chum still steady pretty much, 6 day closure	0.00	786.01
Sat	9/4/2010	0:00:00	23:59:59	24.00	0	0.00%	807	49	11	4	38	12.8	55	pulse 2 must be, more broads and shees real steady	0.00	807.01
Sun	9/5/2010	0:00:00	23:59:59	24.00	0	0.00%	837	34	9	5	30	12.7	54.9	water very slowly dropping, whitefish coming?	0.00	837.01
Mon	9/6/2010	0:00:00	23:59:59	24.00	0	0.00%	825	23	9	7	41	12.9	55.2	broads and humpie up little, Rock slide at wheel	0.00	825.01
Tue	9/7/2010	0:00:00	23:59:59	24.00	0	0.00%	756	52	7	8	28	13.1	55.6	1 week closure over at 6 pm - nobody turned on here	0.00	756.01
Wed	9/8/2010	0:00:00	23:59:59	24.00	0	0.00%	715	35	8	6	33	13.5	56.3	rain rain, making crib raft, winched xtra logs out of river	0.00	715.01
Thu	9/9/2010	0:00:00	23:59:59	24.00	0	0.00%	703	36	4	6	18	14.2	57.6	chum slightly rising, crib done, nobody fishing yet here	0.00	703.01
Fri	9/10/2010	0:00:00	23:59:59	24.00	0	0.00%	648	31	8	7	23	14.2	57.6	chum slightly rising, 260 in crib raft	0.00	648.01
Sat	9/11/2010	0:00:00	23:59:59	24.00	0	0.00%	555	26	4	5	15	14.1	57.4	lots of hunters, 250 more in crib, cc 3x+ rate	0.00	555.01
Sun	9/12/2010	0:00:00	23:59:59	24.00	0	0.00%	443	25	11	9	20	14	57.2	500 crib-closure, cc done, Bill and Wendy sampling	0.00	443.01
Mon	9/13/2010	0:00:00	23:59:59	24.00	0	0.00%	570	67	15	18	34	13.8	57.2	chum up and whitefish building last 2 days	0.00	570.01
Tue	9/14/2010	0:00:00	23:59:59	24.00	0	0.00%	420	68	25	21	20	13.9	57	humpies and broads up more, chum drop	0.00	420.00
Wed	9/15/2010	0:00:00	23:59:59	24.00	0	0.00%	306	45	26	16	22	13.8	56.8	chum down, last pulse gone, big numbers all over now	0.00	306.00
Thu	9/16/2010	0:00:00	23:59:59	24.00	0	0.00%	298	40	25	7	11	13.5	55.9	no fishing cept for daily dog food. 2 camps going	0.00	298.00
Fri	9/17/2010	0:00:00	23:59:59	24.00	0	0.00%	302	58	30	18	29	13.1	55.2	cc pulling wheel, Bill C still here, 6 coho	0.00	302.00
Sat	9/18/2010	0:00:00	23:59:59	24.00	0	0.00%	209	53	22	14	13	12.4	54.3	chum way down, water steady	0.00	209.00
Sun	9/19/2010	0:00:00	23:59:59	24.00	0	0.00%	192	45	30	9	14	12.4	54.3	chum numbers steady, water steady	0.00	192.00
Mon	9/20/2010	0:00:00	12:16:07	12.27	0	0.00%	72	7	8	2	1	11.4	52.5	chum down, bump pulse past, Stopped wheel	0.00	140.85

Table 4

2010 All Species Video CPUE Summary - Rampart Rapids

Start Day	Day No.	Counting Date	King per hr	King per 24 hr	Chum per hr	Chum per 24 hr	Sheefish per hr	Sheefish per 24 hr	Broad per hr	Broad per 24 hr	Humpback per hr	Humpback per 24 hr	Cisco per hr	Cisco per 24 hr
Wed	1	6/16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	28.46
Thu	2	6/17	0.00	0.00	0.00	0.00	0.00	0.00	0.08	1.85	0.08	1.85	1.38	33.23
Fri	3	6/18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	48.00
Sat	4	6/19	0.00	0.00	0.00	0.00	0.08	1.85	0.08	1.85	0.00	0.00	2.15	51.69
Sun	5	6/20	0.00	0.00	0.00	0.00	0.08	1.85	0.00	0.00	0.00	0.00	1.31	31.38
Mon	6	6/21	0.00	0.00	0.00	0.00	0.00	0.00	0.15	3.69	0.08	1.85	1.08	25.85
Tue	7	6/22	0.00	0.00	0.00	0.00	0.00	0.00	0.31	7.38	0.23	5.54	4.08	97.85
Wed	8	6/23	0.08	1.85	0.00	0.00	0.00	0.00	0.31	7.38	0.15	3.69	3.31	79.38
Thu	9	6/24	0.08	1.85	0.00	0.00	0.00	0.00	0.15	3.69	0.00	0.00	6.85	164.31
Fri	10	6/25	0.00	0.00	0.00	0.00	0.08	1.85	0.23	5.54	0.38	9.23	4.31	103.38
Sat	11	6/26	0.15	3.69	0.00	0.00	0.15	3.69	0.46	11.08	0.23	5.54	4.85	116.31
Sun	12	6/27	0.31	7.38	0.00	0.00	0.15	3.69	0.46	11.08	0.31	7.38	2.46	59.08
Mon	13	6/28	0.38	9.23	0.00	0.00	0.08	1.85	0.31	7.38	0.23	5.54	1.92	46.15
Tue	14	6/29	0.59	14.17	0.00	0.00	0.00	0.00	0.17	4.05	0.08	2.02	4.72	113.35
Wed	15	6/30	0.54	13.06	0.00	0.00	0.07	1.63	0.00	0.00	0.14	3.26	4.08	97.91
Thu	16	7/1	0.54	12.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.31	55.38
Fri	17	7/2	1.31	31.38	0.00	0.00	0.08	1.85	0.00	0.00	0.08	1.85	2.00	48.00
Sat	18	7/3	0.69	16.62	0.00	0.00	0.08	1.85	0.08	1.85	0.08	1.85	1.46	35.08
Sun	19	7/4	0.36	8.57	0.21	5.14	0.00	0.00	0.00	0.00	0.14	3.43	1.50	36.00
Mon	20	7/5	1.82	43.64	0.65	15.71	0.00	0.00	0.00	0.00	0.07	1.75	1.38	33.16
Tue	21	7/6	3.38	81.23	1.85	44.31	0.08	1.85	0.00	0.00	0.15	3.69	1.46	35.08
Wed	22	7/7	1.85	44.31	2.92	70.15	0.08	1.85	0.00	0.00	0.15	3.69	3.85	92.31
Thu	23	7/8	0.62	14.77	2.77	66.46	0.00	0.00	0.00	0.00	0.15	3.69	4.08	97.85
Fri	24	7/9	1.92	46.15	3.62	86.77	0.00	0.00	0.08	1.85	0.00	0.00	2.08	49.85
Sat	25	7/10	1.85	44.31	1.69	40.62	0.00	0.00	0.00	0.00	0.00	0.00	0.85	20.31
Sun	26	7/11	1.77	42.46	1.31	31.38	0.00	0.00	0.00	0.00	0.08	1.85	0.38	9.23
Mon	27	7/12	1.77	42.46	1.08	25.85	0.00	0.00	0.08	1.85	0.08	1.85	0.54	12.92
Tue	28	7/13	2.41	57.74	2.07	49.78	0.08	1.99	0.00	0.00	0.08	1.99	1.00	23.89
Wed	29	7/14	1.00	24.00	2.00	48.00	0.15	3.69	0.00	0.00	0.00	0.00	0.77	18.46
Thu	30	7/15	0.15	3.69	1.62	38.77	0.00	0.00	0.08	1.85	0.00	0.00	1.38	33.23
Fri	31	7/16	1.08	25.85	2.00	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	20.31
Sat	32	7/17	0.46	11.08	2.54	60.92	0.00	0.00	0.08	1.85	0.08	1.85	0.92	22.15
Sun	33	7/18	0.46	11.08	2.38	57.23	0.00	0.00	0.00	0.00	0.08	1.85	2.54	60.92
Mon	34	7/19	1.46	35.08	3.62	86.77	0.00	0.00	0.00	0.00	0.08	1.85	3.15	75.69
Tue	35	7/20	1.08	25.85	3.38	81.23	0.15	3.69	0.08	1.85	0.08	1.85	5.23	125.54
Wed	36	7/21	0.62	14.77	4.23	101.54	0.15	3.69	0.15	3.69	0.15	3.69	8.62	206.77
Thu	37	7/22	0.31	7.38	2.15	51.69	0.08	1.85	0.00	0.00	0.08	1.85	9.69	232.62
Fri	38	7/23	0.38	9.23	2.23	53.54	0.00	0.00	0.00	0.00	0.00	0.00	7.77	186.46
Sat	39	7/24	0.15	3.69	1.00	24.00	0.08	1.85	0.00	0.00	0.00	0.00	4.54	108.92
Sun	40	7/25	0.15	3.69	1.23	29.54	0.23	5.54	0.00	0.00	0.08	1.85	2.77	66.46
Mon	41	7/26	0.31	7.38	1.08	25.85	0.00	0.00	0.15	3.69	0.08	1.85	1.69	40.62
Tue	42	7/27	0.23	5.54	1.54	36.92	0.15	3.69	0.00	0.00	0.23	5.54	0.77	18.46
Wed	43	7/28	0.15	3.56	1.93	46.29	0.15	3.56	0.07	1.78	0.07	1.78	1.26	30.27
Thu	44	7/29	0.38	9.23	1.08	25.85	0.08	1.85	0.08	1.85	0.08	1.85	7.85	188.31
Fri	45	7/30	0.57	13.71	1.50	36.00	0.07	1.71	0.21	5.14	0.07	1.71	8.21	197.14
Sat	46	7/31	0.42	10.00	3.92	94.00	0.25	6.00	0.25	6.00	0.00	0.00	8.00	192.00
Sun	47	8/1		5.00										
Mon	48	8/2	0.00	0.00	4.73	113.64	0.46	10.93	0.00	0.00	0.36	8.74	9.65	231.65
Tue	49	8/3	0.29	6.99	6.70	160.84	0.29	6.99	0.00	0.00	0.29	6.99	8.38	201.05

Table 5

2010 All Species Video CPUE Summary - Rampart Rapids														
Start Day	Day No.	Counting Date	King per hr	King per 24 hr	Chum per hr	Chum per 24 hr	Sheefish per hr	Sheefish per 24 hr	Broad per hr	Broad per 24 hr	Humpback per hr	Humpback per 24 hr	Cisco per hr	Cisco per 24 hr
Wed	50	8/4	0.04	1.00	4.92	118.00	0.21	5.00	0.08	2.00	0.08	2.00	6.17	148.00
Thu	51	8/5	0.13	3.00	6.33	152.00	0.54	13.00	0.04	1.00	0.08	2.00	3.88	93.00
Fri	52	8/6	0.04	1.00	6.79	163.00	0.29	7.00	0.04	1.00	0.08	2.00	2.00	48.00
Sat	53	8/7	0.17	4.00	11.75	282.00	0.58	14.00	0.08	2.00	0.08	2.00	2.79	67.00
Sun	54	8/8	0.00	0.00	16.83	404.00	0.71	17.00	0.08	2.00	0.21	5.00	3.04	73.00
Mon	55	8/9	0.04	1.00	9.46	227.00	0.25	6.00	0.04	1.00	0.29	7.00	4.08	98.00
Tue	56	8/10	0.00	0.00	15.83	380.00	0.17	4.00	0.08	2.00	0.13	3.00	4.13	99.00
Wed	57	8/11	0.04	1.00	17.29	415.00	0.08	2.00	0.00	0.00	0.04	1.00	8.46	203.00
Thu	58	8/12	0.13	3.00	19.54	469.01	0.08	2.00	0.04	1.00	0.00	0.00	19.42	466.01
Fri	59	8/13	0.04	1.00	29.25	702.01	0.08	2.00	0.04	1.00	0.08	2.00	28.58	686.01
Sat	60	8/14	0.00	0.00	25.38	609.24	0.27	6.46	0.00	0.00	0.09	2.15	28.79	691.04
Sun	61	8/15				629.85								
Mon	62	8/16				650.46								
Tue	63	8/17	0.00	0.00	27.96	671.07	0.83	19.83	0.00	0.00	0.28	6.61	22.59	542.15
Wed	64	8/18	0.00	0.00	18.63	447.01	0.92	22.00	0.04	1.00	0.04	1.00	16.58	398.00
Thu	65	8/19	0.00	0.00	9.08	218.00	0.46	11.00	0.08	2.00	0.04	1.00	6.50	156.00
Fri	66	8/20	0.00	0.00	7.88	189.00	0.88	21.00	0.08	2.00	0.13	3.00	4.50	108.00
Sat	67	8/21	0.04	1.00	6.42	154.00	1.17	28.00	0.00	0.00	0.13	3.00	4.25	102.00
Sun	68	8/22	0.00	0.00	5.17	124.00	1.17	28.00	0.04	1.00	0.04	1.00	5.17	124.00
Mon	69	8/23	0.04	1.00	4.42	106.00	0.96	23.00	0.04	1.00	0.04	1.00	2.17	52.00
Tue	70	8/24	0.00	0.00	6.42	154.00	1.50	36.00	0.08	2.00	0.08	2.00	2.71	65.00
Wed	71	8/25	0.00	0.00	8.29	199.00	0.83	20.00	0.04	1.00	0.00	0.00	5.13	123.00
Thu	72	8/26	0.00	0.00	12.04	289.00	1.25	30.00	0.17	4.00	0.08	2.00	12.33	296.00
Fri	73	8/27	0.00	0.00	21.00	504.01	1.17	28.00	0.04	1.00	0.08	2.00	14.08	338.00
Sat	74	8/28	0.00	0.00	25.21	605.01	1.79	43.00	0.13	3.00	0.00	0.00	12.63	303.00
Sun	75	8/29	0.00	0.00	30.71	737.01	1.88	45.00	0.21	5.00	0.08	2.00	7.17	172.00
Mon	76	8/30	0.04	1.00	42.00	1008.01	2.33	56.00	0.25	6.00	0.21	5.00	4.29	103.00
Tue	77	8/31	0.00	0.00	39.90	957.58	2.47	59.37	0.23	5.50	0.09	2.20	2.15	51.67
Wed	78	9/1	0.00	0.00	35.25	846.01	2.21	53.00	0.13	3.00	0.17	4.00	2.29	55.00
Thu	79	9/2	0.00	0.00	33.92	814.01	2.21	53.00	0.08	2.00	0.21	5.00	2.29	55.00
Fri	80	9/3	0.00	0.00	32.75	786.01	2.21	53.00	0.25	6.00	0.08	2.00	1.92	46.00
Sat	81	9/4	0.00	0.00	33.63	807.01	2.04	49.00	0.46	11.00	0.17	4.00	1.58	38.00
Sun	82	9/5	0.00	0.00	34.88	837.01	1.42	34.00	0.38	9.00	0.21	5.00	1.25	30.00
Mon	83	9/6	0.00	0.00	34.38	825.01	0.96	23.00	0.38	9.00	0.29	7.00	1.71	41.00
Tue	84	9/7	0.00	0.00	31.50	756.01	2.17	52.00	0.29	7.00	0.33	8.00	1.17	28.00
Wed	85	9/8	0.00	0.00	29.79	715.01	1.46	35.00	0.33	8.00	0.25	6.00	1.38	33.00
Thu	86	9/9	0.00	0.00	29.29	703.01	1.50	36.00	0.17	4.00	0.25	6.00	0.75	18.00
Fri	87	9/10	0.00	0.00	27.00	648.01	1.29	31.00	0.33	8.00	0.29	7.00	0.96	23.00
Sat	88	9/11	0.00	0.00	23.13	555.01	1.08	26.00	0.17	4.00	0.21	5.00	0.63	15.00
Sun	89	9/12	0.00	0.00	18.46	443.01	1.04	25.00	0.46	11.00	0.38	9.00	0.83	20.00
Mon	90	9/13	0.00	0.00	23.75	570.01	2.79	67.00	0.63	15.00	0.75	18.00	1.42	34.00
Tue	91	9/14	0.00	0.00	17.50	420.00	2.83	68.00	1.04	25.00	0.88	21.00	0.83	20.00
Wed	92	9/15	0.00	0.00	12.75	306.00	1.88	45.00	1.08	26.00	0.67	16.00	0.92	22.00
Thu	93	9/16	0.00	0.00	12.42	298.00	1.67	40.00	1.04	25.00	0.29	7.00	0.46	11.00
Fri	94	9/17	0.00	0.00	12.58	302.00	2.42	58.00	1.25	30.00	0.75	18.00	1.21	29.00
Sat	95	9/18	0.00	0.00	8.71	209.00	2.21	53.00	0.92	22.00	0.58	14.00	0.54	13.00
Sun	96	9/19	0.00	0.00	8.00	192.00	1.88	45.00	1.25	30.00	0.38	9.00	0.58	14.00
Mon	96	9/20	0.00	0.00	5.87	140.85	0.57	13.69	0.65	15.65	0.16	3.91	0.08	1.96

Table 6

2010 Date	Seechi Disk (cm) 1 readings	Water Temp. C		2010 Date	Seechi Disk (cm) 1 readings	Water Temp. C
6/16/10	21	16.47		8/4/10	10	17.20
6/17/10	19	16.30		8/5/10	10	17.66
6/18/10	16	16.29		8/6/10	11	17.84
6/19/10	16	16.05		8/7/10	13	17.84
6/20/10	17	16.00		8/8/10	13	17.90
6/21/10	18	16.27		8/9/10	11	17.71
6/22/10	16	16.66		8/10/10	10	17.18
6/23/10	18	17.12		8/11/10	10	16.61
6/24/10	20	17.52		8/12/10	8	16.22
6/25/10	24	17.64		8/13/10	6	15.30
6/26/10	25	17.74		8/14/10	6	15.17
6/27/10	25	17.85		8/15/10	7	15.07
6/28/10	22	18.05		8/16/10	7	15.02
6/29/10	20	18.19		8/17/10	7	14.92
6/30/10	20	18.10		8/18/10	8	15.10
7/1/10	19	18.37		8/19/10	10	15.21
7/2/10	17	18.52		8/20/10	10	15.22
7/3/10	15	18.43		8/21/10	11	14.90
7/4/10	12	18.43		8/22/10	13	14.48
7/5/10	10	18.59		8/23/10	11	14.46
7/6/10	10	17.96		8/24/10	10	14.56
7/7/10	11	17.83		8/25/10	8	14.26
7/8/10	8	17.79		8/26/10	6	13.41
7/9/10	8	18.03		8/27/10	6	12.95
7/10/10	9	18.31		8/28/10	5	12.64
7/11/10	8	18.64		8/29/10	7	12.20
7/12/10	9	18.60		8/30/10	8	12.03
7/13/10	11	18.31		8/31/10	9	12.14
7/14/10	11	17.73		9/1/10	12	12.13
7/15/10	10	17.02		9/2/10	15	12.23
7/16/10	8	16.50		9/3/10	16	12.28
7/17/10	10	16.14		9/4/10	18	12.08
7/18/10	9	15.82		9/5/10	20	12.11
7/19/10	9	15.44		9/6/10	21	12.10
7/20/10	9	15.43		9/7/10	23	11.95
7/21/10	8	15.85		9/8/10	24	11.98
7/22/10	10	16.25		9/9/10	25	12.04
7/23/10	11	16.47		9/10/10	25	12.08
7/24/10	10	16.60		9/11/10	24	12.03
7/25/10	8	16.72		9/12/10	26	11.98
7/26/10	9	17.00		9/13/10	26	11.92
7/27/10	11	17.20		9/14/10	24	11.73
7/28/10	12	17.29		9/15/10	26	11.50
7/29/10	12	16.90		9/16/10	26	11.31
7/30/10	9	16.61		9/17/10	24	10.92
7/31/10	8	16.37		9/18/10	24	10.47
8/1/10	8	16.40		9/19/10	26	9.90
8/2/10	8	16.60		9/20/10	27	9.41
8/3/10	9	16.82		9/21/10		