Eagle Sonar Report

An Evaluation of the Sonar Site at Six Mile Bend

Prepared for:
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Abstract

In 2005 the Alaska Department of Fish and Game installed a sonar site on the Yukon River near Eagle Alaska. The primary goal of the site is to enumerate Pacific salmon escapement into the Canadian portion of the river. The authors, under contract by Yukon River Panel Restoration and Enhancement Fund (CRE-110N-5), were hired to evaluate the potential of the site based on our participation during the 2005 field season. This report documents our conclusions in terms of a number of factors including site location, bathymetry, substrate, fish behaviour and species composition. We conclude that, while some aspects of the program require further development, the site and choice of sonar equipment show excellent potential for providing consistent salmon passage estimates. Based on this conclusion, we propose three options for DFO participation with ADF&G in the operation of the site.

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Introduction

Background

The Yukon River is a major transboundary river system with salmon populations that spawn in both American and Canadian territory. Chinook and chum salmon are caught in the various rivers and streams of this watershed by both countries and are jointly managed by the Alaska Department of Fish and Game (ADF&G), United States Fish and Wildlife Service (USFWS), and Fisheries and Oceans Canada (DFO) through the bilateral Yukon Panel. One of the prime management concerns is the relative proportion of both these species that is produced by each country. Therefore, estimation of the numbers of Chinook and chum salmon that enter Canada (hereafter called the Canadian production) is an important focus for optimal management of the fisheries and spawning stocks.

In addition to Canadian attempts to estimate the Canadian production using a mark and recapture program, the US performs scale pattern analysis to determine relative production and, more recently, DNA has played a role in the apportionment of catch and escapement. In the Canadian program, marking is carried out by DFO at a field site on the Yukon River, near the Yukon/Alaska border, using fish wheels for catching the fish to be marked. A portion of these marked fish are subsequently caught either by a commercial fishery in the Yukon River, or by a test fishery operated by DFO. This method has several drawbacks that have lead to potential disagreement between the two countries over the reliability of the estimates.

During the 2005 Yukon River Chinook migration, ADF&G conducted a feasibility study to determine if acoustic methods would provide an improved estimate of the Canadian escapement. Both countries were interested in this study and agreed to have Canadian participation. The authors were subsequently contracted by the Yukon Panel to work at the sonar site and produce a report evaluating its potential. The authors were chosen because of their experience with riverine acoustics as a tool to estimate migrating salmon. They have each worked in this area since 1993 and have participated in programs conducted by both ADF&G and DFO.

Joint operation of this site by ADF&G and DFO could potentially lead to a joint border escapement estimate. In addition it might avoid some of the difficulties that are associated with the mark and recapture program and be able to provide estimates with greater precision and accuracy.

Objectives

The authors had three main objectives: to participate in the field program, to evaluate the site and the acoustic methods being used, and to write a report that would be submitted to the Yukon Panel.

Thumbnail Description of Riverine Acoustics

The most important consideration in riverine acoustics is the site location. A well selected site vastly reduces the complexity of estimating the number of migrating salmon. The two most important components of the site are the river bottom and the current pattern. A flat bottom with a smooth, nonreflective substrate is the optimal choice. The current should be strong enough to discourage fish from resting or milling and should be free from eddies or current shears, i.e., it should have uniform flow. In addition, the site must not include any spawning areas. These factors translate into fish behaviour and fish detection that allow straightforward identification of upstream migrating fish.

Next, one needs to learn what portion of the river cross-section the migrating fish are using. For large, fast flowing rivers such as the Yukon, upstream migrating salmon rarely venture into the high current areas near the middle of the river. Typically they are found near the river banks and near the bottom (locations where the current is low). An ideal bottom profile and low reflective substrate then allow one to aim the acoustic beam close to the bottom and detect fish echoes without observing strong echoes from the substrate.

The final considerations are the species mixture and undesirable fish behaviour. If there is a sizable portion of fish that are not the species of interest, then some type of species apportionment is required. Typically the information for this apportionment does not come from the acoustic data, but requires test fishing at the site. An example of undesirable behaviour would be fish migrating upstream, then back downstream and perhaps repeating this cycle several times. These problems can be addressed, but require more effort such as joining the information from independent sets of data.

The sonar site at Eagle is close to ideal. Thus, the acoustic data lend themselves to straightforward analysis and produce estimates whose confidence interval is affected only by the variance from one type of data. In this report, we examine several potential problems, such as species composition, migrating salmon in areas of the river cross section not covered by the acoustic beam, etc. This was done to discover if there were any difficulties that might preclude using a simple estimate. We concluded that, at least during the period of our field work, we could find no evidence of significant additional problems. This situation may change with time, requiring continued checking. However, over time, the level of checking may be able to be reduced.

Site Location and Description

The sonar site is on the Yukon River in Eastern Alaska near the city of Eagle. Eagle is roughly 8 miles downstream of the Alaska/Yukon border. The site is located a further 6 miles downstream from Eagle at a location known locally as Six Mile Bend (N 64° 87.79’ W 141° 07.96’).

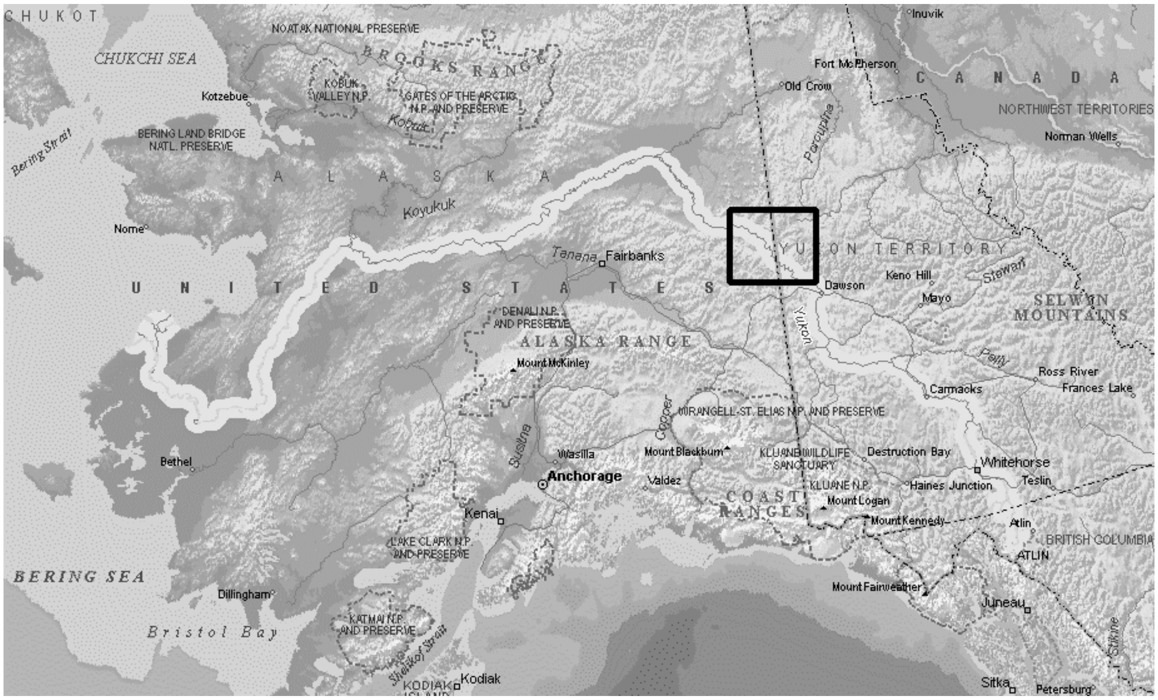

Fig. 1 Map showing the Yukon River and outlining the Alaska/Yukon border area where the Eagle sonar site is located.

During the field season, the width of the river at this location fluctuated between 350-400m. The thalweg, the deepest point of the river, is roughly 100m from the right bank with a depth of about 10m and current velocity estimated to be approximately 3m/s. (Note that we use the international convention of referring to left and right banks, which is with reference to looking downstream.)

Bottom Profiles at Sonar Site

Right and left bank sonar transducer locations were chosen to take advantage of the flattest bottom profiles with fewest obstacles present on each bank. Therefore, they were not directly facing each other across the river. The right bank sonar was located approximately 100m upstream from the left bank sonar. Figure 2 shows the bottom profiles out to the thalweg from each bank. Note that the distances from shore are relative to where the sounding transect began, not the river bank. Left bank transects began within approximately 20m of shore while the right bank began within about 10m.

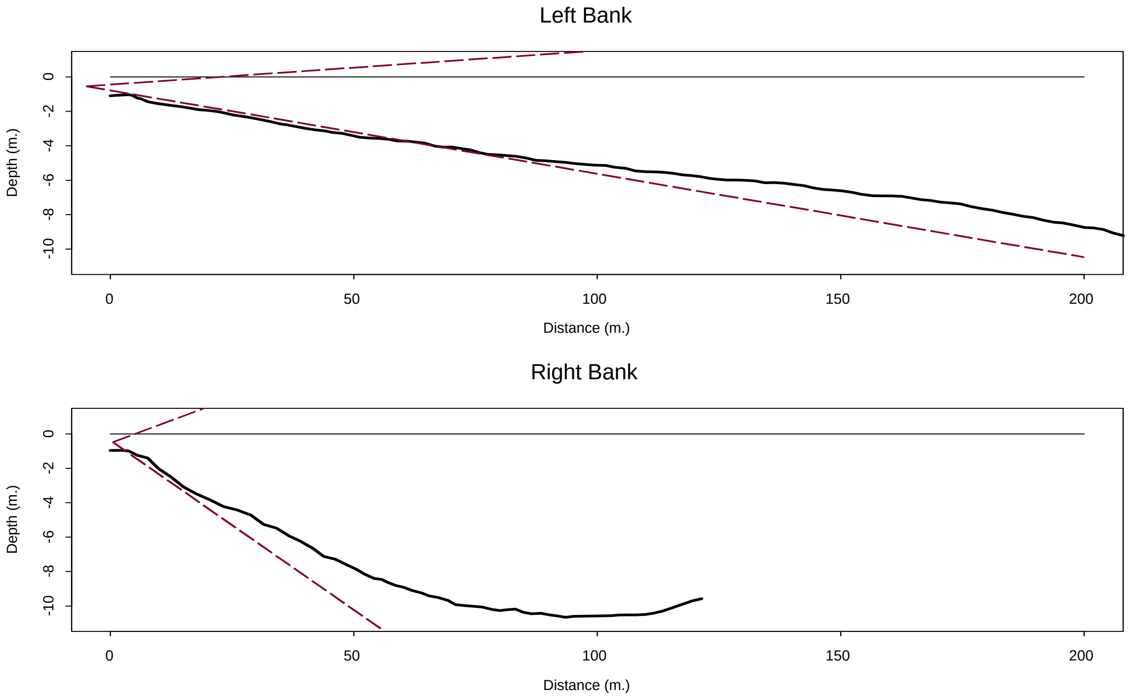

Fig. 2 River bottom profiles (thick black line) and water surface (thin black line) are shown for both banks. In addition, the acoustic beam has been overlaid (dashed red lines) for the split-beam (left bank) and DIDSON (right bank) sonar systems.

Because the acoustic beam is triangular in vertical cross-section, it is desirable if the bottom profile of the site is roughly triangular as well. This allows the beam to be positioned so that its “edges” closely follow the surface and bottom contours. Undulations or protrusions in the bottom profile may result in excessive noise where the substrate rises into the beam and detection gaps where the bottom dips below the beam.

From the plots in Fig.2 it is clear the vertical beam angles on both banks were too large to fit in the available water column. This resulted in noise due to echoes from the bottom and from waves on the surface. This topic will be addressed later in this report.

Site Description, Equipment and Methods

Site Description

The Eagle sonar project base camp was located on the Yukon River at Six Mile Bend approximately six miles downstream from Eagle, Alaska (Fig. 3). Structures at the site included a cook tent, five sleeping tents, storage shed and outhouse. The sonar tent and the sonar units were located a further half mile downstream in a gently curving reach of river with no islands or braiding. In this section the thalweg is much closer to the right bank than to the left (Fig. 2).

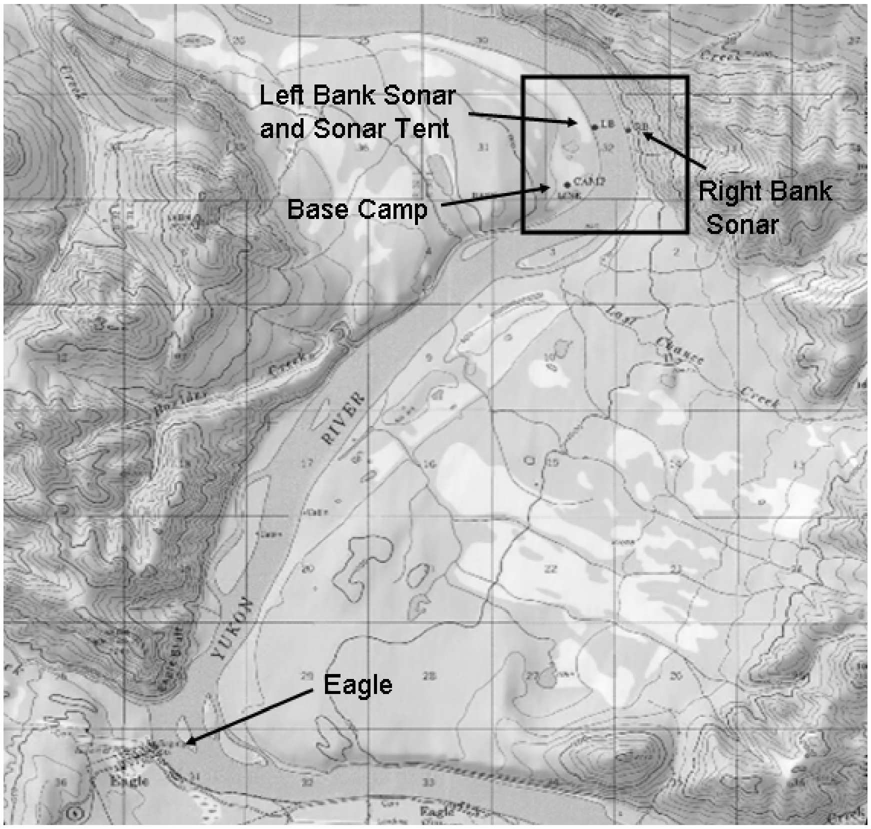

Fig. 3 Map showing the location of the town of Eagle, the sonar base camp, sonar tent, left and right bank transducer locations.

The beach on the right bank originates at the base of a steep hillside, and is composed primarily of flat shale or slate, cobble and boulders interspersed with gravel. The substrate beyond the beach was of similar material as far offshore as could be explored by staff in chest waders and has a slope of approximately 7.6°. Test fishing and attempts at anchoring in deeper water indicated the midstream substrate to be large boulders. The beach on the left bank is gently sloping from a low rise of about 3m. Silt and gravel form the substrate near the top of the beach giving way to cobble interspersed with gravel lower down. Cobble and gravel with occasional embedded large boulders continued offshore as far as one was able to wade. The left bank substrate has a slope of approximately 2.5°.

The present site has many features that make it a good location for estimation of migrating fish with sonar. These include:

Single Channel

The Eagle site has a single river channel. Islands and braided channels greatly increase the difficulty of estimation. Usually, in a single channel, only two sonar units are required, one on each bank. In river channels containing islands, additional units are required on each side of each island, increasing the costs. Braided channels pose similar problems and in addition are often shallow. This limits the range at which fish can be readily detected.

Triangular Cross-Section

Figure 2 shows the bottom profiles with the acoustic beams overlaid. Beam angles are exaggerated due to the disproportionate scales of the plots. The sonar locations on both banks have a flat bottom most of the way to the thalweg.

On the left bank the noise from the bottom was minimized by aiming the transducer with more of the beam intercepting the river surface. This was the best solution since the river surface normally reflects very little sound back towards the transducer. However, during periods of high wind, waves on the river were clearly visible on the echogram. This was not a critical problem and would be greatly reduced by using a transducer with a vertical beam-width equal to, or smaller than, the angle formed between the river surface and bottom.

The imaging sonar on the right bank was affected differently by the large beam-width of the DIDSON sonar. When operating with the transducer in the normal horizontal position, there was little evidence of the beam hitting the river surface and the image of bottom and fish was clear. However, when operating with the transducer rotated 90° (into the vertical position) the water surface showed faintly near the central axis of the image and a wavering reflection of the bottom appeared on the opposite side of the image from the true bottom. The images of fish passing through the beam were duplicated in the reflection as well.

Strong Current with Unbroken Flow and no Eddies

In this section of river the current is strong and the flow pattern is uniformly downstream. The lack of eddies and discontinuities in the current serves to discourage holding or milling behaviour. Fish traveling consistently upstream are much easier to count with sonar than those that wander about, or make multiple passes through the sampling area.

Suitable Substrate

Although a flat silt bottom is probably the best natural substrate for acoustic work, the cobble and small boulder throughout this site makes a suitable bottom for fish detection. Also, the bottom is not stepped in the way silt bottoms frequently are. The large boulders at the site are distributed sparsely enough so that the transducers can be aimed along unobstructed paths. The acoustic reflection from the bottom was sufficiently lower than the echoes from the fish to allow fish to be detected by the split-beam sonar. Fish detection with the imaging sonar is less sensitive to bottom reflections because the motion of the fish against the background is eye-catching during manual counting from the screen image.

Vessel Traffic

Canoes, kayaks and small outboard-propelled boats pass through the study area daily during the summer months. The numbers are quite variable, but are rarely more than 10-20 per day. The strong current makes traveling close to the beach advantageous for low powered vessels, the wakes of which temporarily obscure a considerable portion of acoustic beam. However vessel traffic is usually traveling straight through, so its effect is short-lived and the overall impact is negligible.

Substrate Composition with respect to In-Stream Structures

The substrate at the beaches is primarily cobble interspersed with gravel. This is very suitable for the installation of the movable pole-suspended weirs used to deflect fish offshore into the acoustic beams. During large fluctuations in water level, these weirs are moved daily and require steel poles to be driven into the bottom as supports for the wire mesh. The poles can be driven into this substrate fairly easily and once in place are quite sturdy.

Although the site has many features that satisfy the technical requirements for counting fish with sonar, it suffers disadvantages due to its remote location:

Access

There is no road access to the sonar site. All supplies and personnel must be transported 6 miles from Eagle by boat. Gravel road access to Eagle is available during the warmer months and there is daily air service, although shipping by air proved erratic and unreliable.

Communications

Local communication was monitored on a regular basis by the sonar camp, the store in Eagle and nearby people living along the river using marine VHF radios. The only communication to locations beyond Eagle was by satellite phone, which was intermittent and unreliable. Frequently calls could not be connected or were disconnected abruptly before the call was completed. Land-line telephone is available in Eagle, but the line quality is very poor and calls sometimes terminated unexpectedly. Fax transmission from Eagle ranged from difficult to impossible. The Eagle library offers internet to the public during their regular hours of operation. Some residents in the area use satellite internet connections through a commercial service (StarBand). Although we had no direct experience with this service, word of mouth reports indicated it worked well. True broadband satellite internet service at the sonar site could overcome many of the communications difficulties experienced by the staff during the 2005 season.

Sonar

Right Bank

Since upstream migrating fish were expected to be swimming close to shore on the right bank a DIDSON sonar was used. This is a multi-beam imaging sonar manufactured by Sound Metrics of Seattle, WA, and produces video-like images of objects in the water. These images can be looked at one frame at a time, or played back at various speeds to produce a video-like image with moving fish. The sonar is comprised of a wet end transducer/electronics package which is connected to a topside computer by Ethernet cable. During operation, data is stored on the topside computer and the acoustic image is displayed in real-time on the monitor. Since data analysis at the Eagle sonar site was performed on the left bank, the DIDSON sonar was connected to the left bank computers by a wireless LAN. This allowed the staff to monitor the right bank sonar at all times and to download data for analysis without traveling across the river.

The beam pattern of this sonar, approximately 30° horizontally by 17° vertically, is more than adequate to ensonify the entire water column at this location. Due to the strong current and close proximity of the thalweg to the right bank, the majority of upstream migrating fish are expected to swim within the DIDSON's 60m range limit.

For relatively short range applications, an imaging sonar such as the DIDSON has an advantage over split-beam because it offers higher resolution in the upstream/downstream direction and higher target detection probability. Though the range limitation was unimportant in this application, a disadvantage of the DIDSON system is its lack of vertical target position information, i.e., only 2D position data are available. Vertical target positions are used to determine the vertical distribution of the fish in the water column. The transducer can be rotated 90° to enable vertical positions to be measured, but this reduces the horizontal beam width to 17° and eliminates horizontal target position information. The horizontal target position is necessary to determine the direction of travel of the fish. One solution is to alternate between the two transducer positions allowing the non-simultaneous acquisition of both types of data. However an alternative solution may be possible as indicated by recent work by DFO (per. comm. George Cronkite). This study demonstrated that rotating the transducer to a position intermediate between 0° and 90° may allow both horizontal and vertical positions to be recorded.

Left Bank

The left bank slopes more gently than the right and has less current, so fish are likely to be more widely distributed from shore. Upstream migrating fish were expected to be swimming as much as 100 meters or more offshore so split-beam sonar was used, in this case a Simrad EK60. The electronics of the EK60 are contained in a topside unit which is a small metal box with connectors for power, the transducer and Ethernet connection to the controlling computer.

Split-beam sonar can be effective up to several hundred meters under ideal conditions; whereas, imaging sonar is generally more restricted in range. Split-beam sonar provides 3-D target position information which allows both direction of travel and vertical distribution of the fish to be determined from the same data set. Some brands of split-beam sonar, such as the EK60, provide the user access to the raw digital data. While the large volume of the raw data requires considerable storage space, when displayed on a monitor it allows the user to detect fish swimming close to noisy backgrounds such as cobble river bottom.

Weirs

Fish migrating upstream often swim close to the bank to avoid strong current. This can result in poor fish detection since outward looking sonar beams are narrowest near the bank and fish may be able to swim over or under the beam. Fish deflection weirs were used on both banks to force fish away from the river bank and into the region ensonified by the sonar. The weir is intended to force the fish out to a range at which the beam covers the entire water column. On the right bank the weir started from shore and extended at a slight angle upstream to a point roughly 3m beyond the transducer and just downstream of the acoustic beam. This was the maximum possible extension of the weir due to the slope of the bank and strong current. The left bank weir angled upstream from the bank to a point just out of the acoustic beam and approximately 10m beyond the transducer.

Test Fishing

Drift Nets

Drift gillnets were used at the sonar site as the method of test-fishing for species composition and as a method of sampling the run for age, sex, length, genetic and fecundity samples. Test fishing was initiated on July 11 and continued through August 10, 2005.

Six 25-fathom by 5 fathom gillnets with 2.75, 4.0, 5.5, 6.5, 7.5, and 8.5-inch mesh sizes were drifted in an area of the river 400m upstream to 400m downstream of the sonar site. Three zones were sampled: the right bank near-shore, the left bank near-shore and the left bank offshore. The right bank near-shore drift covered the area ensonified by the DIDSON out to about 40m from shore. The left bank combined inshore-offshore drifts covered the area ensonified by the split-beam on left bank out to 140m from shore. During the near-shore drifts the inner end of the nets approached to within about 10m of the right bank shoreline and about 20m of the left bank shoreline.

Set Nets

Set nets were not initially included as part of the test fishing strategy, but during the season, drift fishing caught only Chinook salmon while some of the local fish-wheel operators reported catching other species such as whitefish and suckers. This indicated the drift nets may not have been catching a representative sample of the available species, perhaps because the drift nets were deployed a considerable distance from shore. As a result, set nets were deployed on the left bank later in the season to improve the sampling of the near-shore region of the river. A 6.5 inch mesh size gillnet was anchored to shore by metal posts driven into the bank. The offshore end of the net was anchored at the lead-line with several large boulders. A scotchman float tethered to the anchor supported the float-line. The resulting set extended from shore in an arc downstream and fished the region from the beach to approximately 15m offshore.

Data Description and Analysis Methods

Data Description

DIDSON Imaging Sonar Data

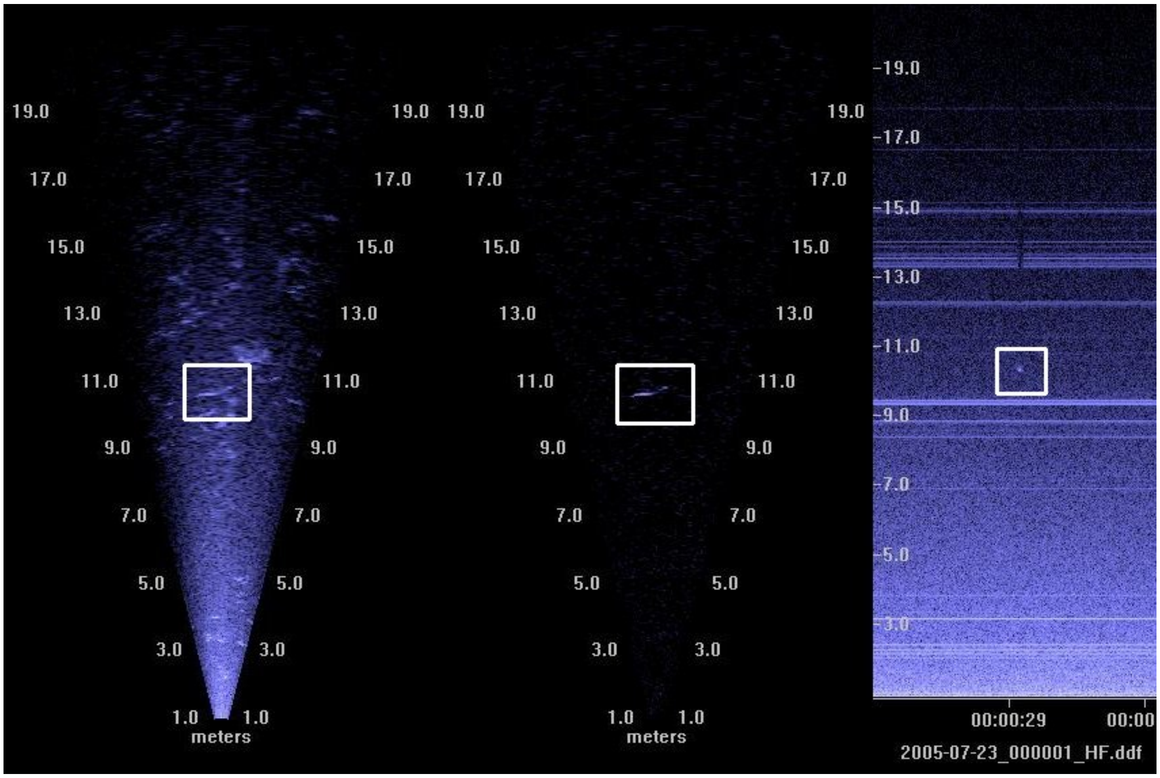

Fig. 4 Left image: a DIDSON frame with fish passing at approx. 11 meters. Middle Image: the same frame as on the left with the non-moving objects automatically removed. Right panel: an echogram of this section of the DIDSON data showing the fish passing through the center of the beam at a range of approximately 11m.

The DIDSON sonar collects data using 48 separate transducers. The raw data is stored in a binary file on the host computer. These files can be used to replay the data at a later time and are also available for more extensive data analysis. The images displayed on the monitor are typically of sufficient quality for the user to distinguish upstream migrating salmon from other fish species and from debris. Two examples of screen images of a DIDSON frame are shown in Fig 4. In addition, an echogram view is available which summarizes the entire sampling period in a plot of targets versus time

(Fig 4, right panel). This allows the user to view and count fish without the necessity of replaying the entire file in real time. While counting from the echogram, verification of target type and direction of travel is accomplished by selecting a region of interest in the echogram with the mouse. The selected region is subsequently replayed in the real-time view so the target can be positively identified.

Simrad EK60 Sonar Data

During the 2005 season, a Simrad EK60 Scientific Sounder connected to a 4°X10° elliptical split-beam transducer was used to collect data on the left bank of the river. In addition to the target position, the sonar measures the target strength (acoustic size of the target) from the amplitude of the signal returned by the target. The EK60 displays a scrolling echogram of echo target strength versus time on the computer monitor while sampling. Different target strength values are represented by different colours on the screen. Using this display the user can usually distinguish fish and debris targets from bottom echoes and can, within limits, enumerate fish directly from the display.

Analysis – Echoview and DIDSON Echogram

Counts of fish images for both banks were obtained visually using the display software for the two different sonar systems. Tallying both banks' data that spanned a 24-hour period required about 8 man-hours/day, once staff were trained and experienced. The 8 hours was necessary for counting fish images, but does not include time for extraction of more detailed information. This additional information includes such things as fish location in the water column that are used to plot fish distributions versus the river cross-section. Counts were completed daily by staff working shifts to ensure that the previous day's count was ready in time for the morning report back to the ADF&G fisheries managers. Analyzing a 3-hour subset of Simrad data for fish distribution plots required one additional hour per day on average.

Analysis of Split-beam Data with Echoview

Split-beam data from the left bank was analyzed using the Echoview software package sold by SonarData Pty. Ltd. of Hobart Australia. This software displays the data as an echogram with user defined colour-coding. Data are plotted with time on the horizontal axis and range on the vertical axis in manageable time segments with a scroll bar to navigate along the time axis. A zoom function allows the data to be viewed at any desired level of magnification. At Eagle the data were displayed in two adjacent windows on the same screen, one using colours to delineate target strength and the other with colours representing the horizontal position of the target in the beam (Fig 5). Due to fish having a greater target strength than the river bottom, they were most easily identified in the target strength window. Having found a target of interest, one then determined its direction of travel by observing the appropriate colour sequence in the horizontal position window. Tracks considered by staff to be migrating salmon were enumerated with a hand-held tally counter. Tallies were entered into a spreadsheet which subsequently calculated passage rates as the sum of these tracks per unit time.

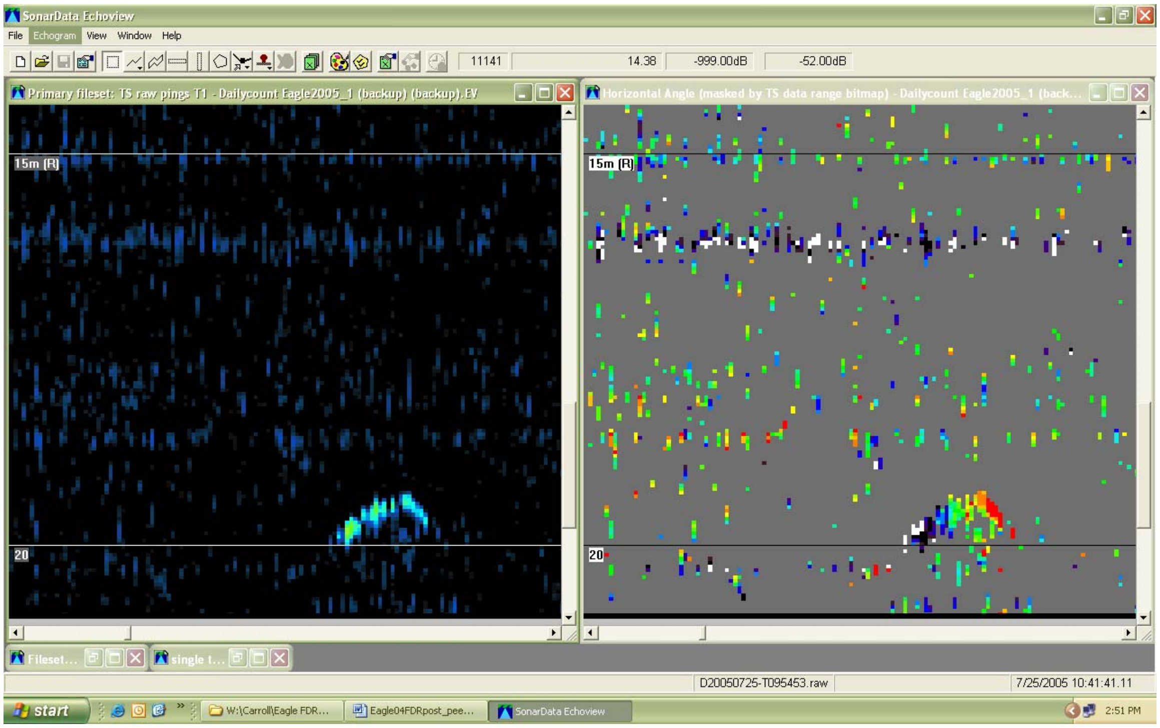

Fig. 5 Example of Echoview in dual window editing mode. The lower portion of the left panel displays the echoes received over time from a single fish. The colour represents the strength of the echo. The right panel shows the same section of data with the colours representing the left/right position of the fish in the acoustic beam. Blue indicates the left-hand side of the beam, while red indicates the right-hand side. Thus, this fish moved from left to right, which is consistent with migrating upstream

As time allowed, further analysis of the split-beam data was done using the fish marking tool in Echoview. Subsets of the data were marked and tracked to provide more detailed information about fish targets such as position, swimming speed and mean target strength. Plots were then made of fish positions overlaid on contours of the river bottom and surface (Fig. 6). These plots are useful for ensuring that the beam ensonifies the entire the water column and that there are no gaps in fish detection. Although not done daily, due to the time-consuming nature of this process when using manual techniques, it was done as often as possible.

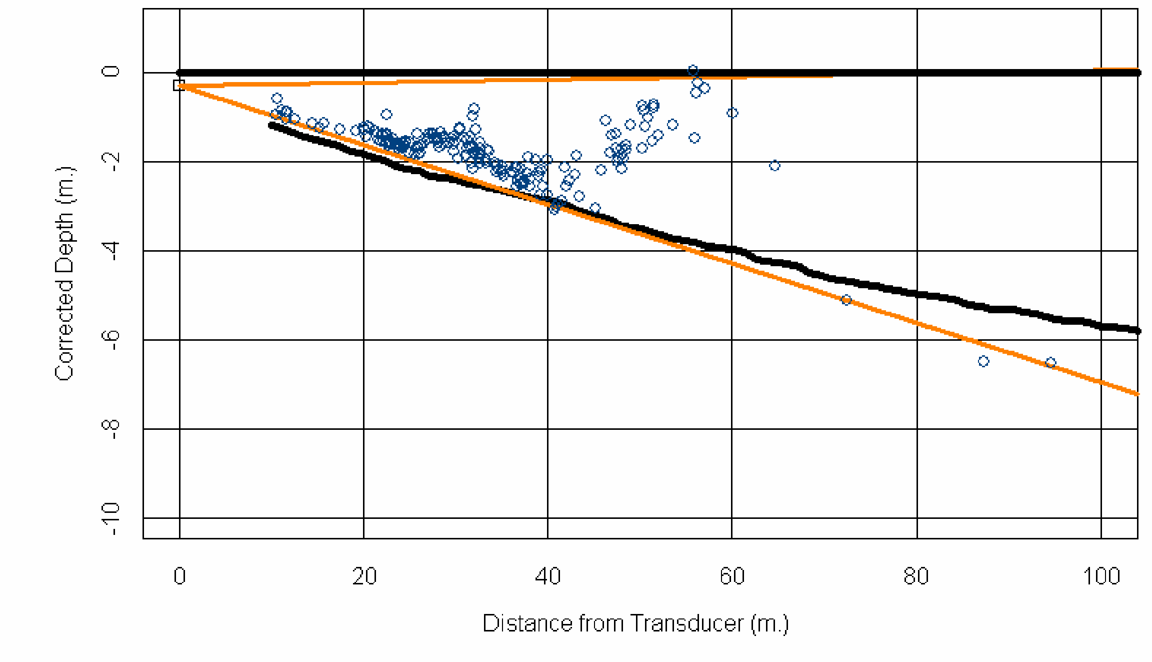

Fig. 6 Plot of split-beam data showing the distribution of fish targets versus the river cross-section profile.

Analysis of DIDSON Data

Salmon enumeration using DIDSON data from the right bank at the Eagle sonar site in 2005 was done using the echogram view described above. Initially, counting was fairly time-consuming. However counting took less and less time as staff became more familiar with the echogram image and less dependant on the real-time view to identify targets. Fish were counted with the mouse marking the fish image on the monitor, using the marking tool option in the DIDSON software. Relevant information from the marked fish was saved in a data file from which the count could be calculated and entered into a spreadsheet. For the Eagle sonar site, which has relatively low passage rates and well separated targets, this approach to counting is very effective.

Daily passage counts were derived from data collected with the transducer in the horizontal position which does not measure the vertical position of fish. Therefore the transducer was rotated 90° for 24 hours to collect data from which the fish distribution in the water column could be plotted. Plots of these data were made in the field which confirmed our opinion that the fish were swimming near bottom. A more detailed analysis of these data will be completed post-season.

Test Fish data

As far as the sonar work was concerned, species composition was the most important information derived from test fishing and the only data which could directly impact the passage estimate. However, sex and length were recorded, scale samples taken for determination of age and genetic and fecundity samples as well. No analysis of the test fishing data was undertaken in the field, since species composition in the drift fishery was uniformly Chinook salmon. The other data and samples from this test fishery were stored for post-season analysis.

Critique of Analysis Methods

Counting Methods

Passage estimates at the Eagle sonar site in 2005 were done by staff visually identifying fish on computer monitors and counting them either by marking on-screen or tallying by hand. The simplicity of this manual system has the advantage that it can be set up and implemented quickly and is easy for relatively inexperienced staff to learn. Its primary limitation is that no ancillary information is produced which can be used to study fish behaviour or carry out system diagnostics. In addition, the sensitivity of this method to the individual subjectivity of the person doing the counting can increase the variability of estimates.

Diagnostic tools, such as beam plots with overlaid fish distributions, are important to ensure counts are a consistent index of fish passage. For example, the plot will indicate if a transducer has become misaligned or if there are gaps in the detection of fish. Scatter plots of targets are also sensitive to failures of split-beam transducer elements. Often, these problems are not apparent in the echogram. Daily application of diagnostic tools ensures that problems threatening the integrity of the estimates are detected quickly so their impact is minimized.

Software-based automated counting systems allow useful statistics to be calculated as part of the counting process including, for example, the position of the fish in the beam, swim speed and direction, and track characteristics. These are tabulated in files which one can use to perform system diagnostics quickly and easily. Also, because automated counting is much faster than visual counting, the user has more time to spend monitoring system performance and can run diagnostic software on a daily basis. However, the automated approach is more complex and requires more experienced staff. The automated counts must be regularly scrutinized to verify the quality of results. For this reason the introduction of more sophisticated data analysis methods should be gradual and should be compared with results from the existing manual process.

Species Composition

Virtually all test fishing in 2005 was done by drift fishing of gillnets from a boat. This fishing method sampled the middle portion of the river well, but because the boat, with the engine running, could not drift close to shore, the near-shore portion of the river was not sampled. Because the strong current at this site encourages fish to swim inshore, test fishing in this region is crucial to an accurate estimate of species composition. This was revealed by the fact that the drift fishing caught only Chinook salmon; whereas, fish-wheel operators in the vicinity were reporting other species such as whitefish and chum salmon. When a set net was deployed in the near-shore area near the end of the season, it immediately began catching low numbers of chum salmon.

An accurate estimate of species composition will require a combination of fishing techniques which cover the entire river cross-section in a representative manner. Drift fishing is effective for offshore sampling, while set nets and beach seining are two possibilities for sampling the near-shore regions of the river. Drift fishing intensity can likely be reduced due to the day-to-day consistency of the catch. The time made available could be spent on the near-shore fishing, which is likely to be more difficult and time-consuming.

Although split-beam sonar does not directly detect fish size, the measured target strength (the energy of the fish's echo) is sufficiently correlated with fish length to allow one to distinguish between species that differ markedly in size. As a rule of thumb, fish species with length distributions that either overlap slightly or not at all are reasonable candidates for discrimination using target strength. A comparison of length distributions from the test fish catch with the observed target strength distributions will indicate whether sufficient separation exists to be useful as a species apportionment tool.

Portion of River Ensonified

The combined coverage of both sonars allowed insonification of approximately 160m of the 350-400m river width. In addition, another 15m to 20m was blocked by weirs extending from the beaches. Therefore, roughly half the river width was sampled acoustically. This extent of sampling was deemed adequate based on the assumption that fish would prefer swimming nearer the river bank to avoid the full speed of the midstream current. This assumption was supported by visual inspection of the echograms and preliminary analysis of track positions. On the left bank, the Simrad sonar detected most upstream migrants 10-60m from the transducer. The number of migrants dropped sharply as the range increased from 60m to the maximum recorded range of 125m. On the right bank, the DIDSON sonar detected most upstream migrants 3-30m from the transducer. Again, the number of migrants tapered sharply from 30m to the maximum range of 40m.

In an attempt to determine the extent of fish migration near the middle of the river, a boat with a DIDSON sonar mounted on the gunwale was anchored near midstream to observe passage. The current caused too much turbulence around the transducer to allow operation. Also, retrieving the anchor proved difficult and potentially dangerous. Drifting with the same boat allowed the sonar to operate, but the resulting image was hard to interpret since the sonar was difficult to aim and the image moved quickly. The background subtraction function used to detect moving objects in the image was of no use in this circumstance, since it requires a stationary background.

During periods of low flow, fish may swim farther from shore due to decreased current speed. However, as the river drops, the transducers will be constantly re-positioned farther offshore in step with the falling water level. This procedure will reduce the size of the unsampled midstream portion of river. In addition, reduced current speed may allow for the installation of longer weirs and for transducers to be placed farther from the shoreline.

A final resolution of this question will likely require transducers to be mounted far enough offshore to ensonify the entire midstream section of the river. This approach is difficult due to the requirement of placing transducers in regions of higher current speed, but is feasible with split-beam sonar. However, an offshore transducer must be located with an unobstructed view of the midstream portion of the river. If fish passage is found to be low or non-existent in this region, full-time midstream monitoring would not be necessary. Periodic checks throughout the field season would suffice.

Local Catch

To obtain an estimate of the Canadian escapement, account must be taken of the catch that occurs between the sonar site and the US/Canadian border. This will entail some type of monitoring of this local fishery.

Options for DFO Participation

In discussions with ADF&G personnel, in particular Carl Pfisterer and Roger Dunbar, it was made clear to us that Canadian participation in the operation of the Eagle sonar site is welcome. During our participation in 2005 we were treated very well by ADF&G personnel and they appreciated our involvement, particularly in the technical aspects of the work. We were left with the impression that ADF&G regards further collaboration with Canadian fisheries representatives on this project as essential to maintaining a process that is transparent and credible to all parties concerned.

To be effective, participants should have enough experience with riverine sonar and fisheries field work to act as crew chief of a sonar site. While it is unlikely they will be required to take over supervisory duties, they will need a well-rounded knowledge of fisheries sonar and need to be qualified to evaluate decisions affecting quality of the data and overall performance of the site. Continuity of personnel from year to year is also important. This allows the development of a familiarity with site specific idiosyncrasies, trends in methodology, and long term objectives.

We present three options for Canadian participation:

None

The Eagle sonar site shows good potential to provide sound estimates of salmon passage. Since ADF&G appears committed to continue the project, the least expensive option for Canada would be to accept these counts on faith and leave the project operation in the hands of ADF&G. Clearly, though, this leaves DFO with little basis upon which to build confidence in the data and a weak footing from which to engage in discussions of concerns about the data. Perhaps most importantly, the lack of joint participation fails to take advantage of the potential that this project has to provide bilateral agreement on the Canadian production.

DFO Employee

Ideally, the most direct involvement by Canada can be accomplished by placing an experienced DFO employee on-site for the duration of each field season. Ongoing participation by the same employee from year to year assures continuity, in-house expertise and a rigorous understanding of the project. Hiring an individual possessing the full experience and skills necessary for the position might prove difficult. However, DFO has some of the most experienced riverine acoustics personnel in North America working in the Applied Technology Section at the Pacific Biological Station. The training of a technically inclined individual who already possesses a background in fisheries field work by this group would provide the extra skills necessary to match the requirements for the job.

A drawback with this approach is the potential difficulty of justifying continued assignment of an employee to the sonar project at times when more pressing issues arise. Intermittent or part-time participation in the project would undermine both DFO's confidence in the project and the employee's familiarity with its operation.

Consultant

While participation by DFO would be less direct, engaging a consultant to represent Canada would be no more costly than assigning a full-time employee. This option also allows for dependable involvement as delimited by the terms of the contract. A consultant should be expected to possess the necessary technical proficiency for the task, thereby obviating the training of personnel. Disadvantages of this option are that DFO staff would not gain first-hand experience with the project and there would be only partial control over the long term continuity of individual staff.

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