

Hydroacoustic Working Group (HaWG) meeting

14&15 Dec 2004

Review of 2004 Mission Hydroacoustic Program

Present: DFO – George Cronkite, Hermann Enzenhofer, John Holmes, Tim Mulligan
PSC – Jim Cave, Andrew Gray, Ian Guthrie, Mike Lapointe, Fiona Martens,
Yunbo Xie, Itsuo Yesaki

Joint meeting involving hydroacoustic staff from DFO and the PSC to review the process used to estimate daily upstream sockeye salmon escapement at Mission in 2004 with the knowledge that a formal post-season review of 2004 sockeye salmon management would be conducted and that the Mission program would be scrutinized as part of this review process.

The objectives of this meeting included:

1. Examine operational issues affecting the reliability of split-beam hydroacoustic estimates identified by PSC staff in memo to Fraser River Panel Technical Committee (19 Aug 2004 – attached) and DFO comments (09 Nov 2004 – attached);
2. Develop a process to be used in deriving final "in-season estimates of daily passage at Mission" for 2004; and
3. Explore long-term approaches to improve the method by which in-season estimates of daily passage of sockeye salmon in the Fraser River.

Background

DFO and the PSC have collaborated on research designed to improve the hydroacoustic system and processes used to estimate daily upstream passage of sockeye salmon at Mission since 1994. Initially, this collaboration included considerable on-site activity and operational support by DFO at Mission. Around 2002, DFO began reducing its operational support at Mission and began to assume a problem-solving post-season review function and PSC staff took on responsibility for the operation of the Mission facility. Currently, DFO and PSC hydroacoustic staff meet at least annually to conduct a post-season audit of the Mission hydroacoustic facility.

In-season estimates of daily sockeye salmon passage have been made using hydroacoustic technology at Mission since the 1970s. The Fraser River is about 400 m wide at Mission and historically about 60% of migrating fish move along the south bank, about 20% move along the north bank and the remaining 20% of fish move in the middle portion (about 250 m width) of the river. Because of the large width of the Fraser River at Mission, a single acoustic system cannot cover the entire river cross-section. A side-looking (for comparison, the acoustic system on the *Ricker* is deployed in a downward looking configuration) shore-based 200 kHz split-beam acoustic system is currently deployed on the left bank and covers approximately 100-150 m of the cross-

section on a consistent basis (longer ranges are possible when water and wind conditions are extremely calm, but these events are rare). The central portion of the cross-section is transected by a vessel with a downward-looking 33° single-beam system and a downward looking 15° split-beam system. Official estimates of daily passage from the mobile system were derived from the split-beam system in 2004. The single-beam data were collected as backup and for compatibility with the historical legacy.

Two different models are used to estimate the upstream flux of sockeye salmon, depending on the source of the acoustic data. The upstream flux model for the left bank data is

$$N = (U-D)/\Delta t \text{ (fish/sec),}$$

where U = upstream count, D = downstream count, and Δt is the daily sample time. The flux model used for the mobile data is

$$N = T \times (1-2R_d)/L,$$

where T is the total upstream and downstream flux, R_d is the downstream flux ratio, and L is the acoustic beam width at a given depth. The left-bank flux model requires upstream and downstream count data and accurate knowledge of the direction of fish travel, both of which are easily obtained from a stationary system. In order to estimate salmon flux with the mobile system model, estimates of fish velocity and direction of travel are required. These parameters cannot be estimated while the transecting vessel is in motion so periodically throughout a 24 hr period, the vessel will collect stationary data near the left and right banks and in the centre of the river, from which fish speed and direction of travel are estimated using a duration-in-beam technique. This procedure works reasonably well for the single-beam data. However, the split-beam data are confounded by a positional bias toward the beam axis (i.e., target positions are recorded closer to the centre of the beam than is true) that cannot be corrected during the collection or analysis of these data. As a result, the circular 15° split-beam transducer used on the mobile system underestimates fish velocity and produces unreliable direction of travel data. In contrast, the stationary left-bank system, which uses elliptical 2° x 10° and 4° x 10° transducers, is not affected by this positional bias. Therefore, left-bank data are currently used to estimate these parameters and these estimates are applied to the mobile split-beam data across the middle portion of the Fraser River. The use of the left-bank velocity and direction of travel estimates across the entire cross-section is a concern to both DFO and the PSC, but at present there are no alternative methods.

Objective 1: In-season operational Issues

In a memo to the Fraser River Technical Committee dated 19 Aug 2004, PSC staff expressed concern about the reliability of 2004 split-beam in-season estimates. This concern focused on three issues:

- The inclusion of small non-fish targets in the mobile split-beam data,
- Manual cleaning of the mobile split-beam data by term staff on-site failed to remove non-fish targets, and
- Incorrect aiming from the shore-based split system resulted in an incomplete data set.

As a result of these concerns and some data exploration, the PSC proposed a work plan to derive final in-season daily passage estimates at Mission and requested DFO input with respect to the reliability issues that were identified and their work plan. These are not new issues at Mission (or for any hydroacoustic enumeration program), but they seem to have raised more flags this year (2004) than in the past.

A minimum target strength (TS - size of the return echo) threshold value is used for data collection with a sonar system, whether shore-based or mobile. The threshold is set at a value which removes background noise while maintaining the best possible signal-noise-ratio (SNR) for detecting fish. This strategy is designed to allow the optimum number of accepted echoes for a given fish track. In 2004, the threshold setting (TS threshold) on the mobile split-beam echo sounder at Mission was set at -46 dB at the start of the season, which was 6 dB lower than the 2002 and 2003 threshold (-40 dB). The 2004 setting was based on field measurements that showed background noise was lower compared to previous years due to the low discharge conditions in 2004.

We (DFO) consider this approach to threshold setting to be good practice and under normal circumstances we would expect that during data cleaning/analysis a TS-filter (in this case -40 dB) would be applied to the data to remove targets corresponding to small fish (e.g., resident species) or unwanted signals that were tracked by the system prior to estimating upstream passage. However, although it was technically possible to apply a TS-filter during post-processing, PSC staff did not do so until late in July 2004. As a consequence, daily passage estimates for early Stuart fish had to be revised after applying the appropriate TS filter. Our feeling (DFO) is that this issue speaks to a lack of communication between field site and analytical staff within the PSC rather than a systemic problem with the estimation procedure per se.

The second reliability issue concerned the cleaning of mobile split-beam data by on-site term staff. Once these data were cleaned, target density in the split-beam data was higher than in the single-beam data collected concurrently. After some investigation, the PSC concluded that the on-site term staff were accepting non-fish targets (e.g., debris, bottom signal, gas bubbles) as legitimate fish targets, biasing the resulting estimates of fish passage. Additional training was provided to seasonal staff and this improved data quality. Six days of passage data were selected and permanent staff were asked to clean these data and prepare passage estimates. Variability among passage estimates for these 6 days was about 25%, leading the PSC to conclude that all 70 days of data collected in 2004 would likely have to be recleaned in order to derive final in-season passage estimates. However, the greatest difference between in-season estimates based on seasonal staff cleaning and estimates derived from

permanent staff processing occurred on the day of heaviest fish passage. When fish passage was lower (5 of 6 days chosen for comparison), the daily estimates of seasonal and permanent staff were similar.

We (DFO) have two difficulties with this issue as identified. First, the PSC continues to rely on the mobile single-beam data as a reference standard for comparison despite several well known biases in these data. We (DFO) do not believe that this faith is justified, but it seems to result from an unwillingness to abandon the "historic legacy" at Mission. Second, in re-cleaning their data, PSC staff did not develop a standardized approach to data cleaning and as a result different data cleaners applied different criteria. We specifically noted that TS filters were not applied automatically to remove unwanted targets. Instead, a track-by-track assessment was conducted by each staff member, looking at characteristics such as trajectory and average TS. However, the analysis software is designed in such a way that once a track is identified, several additional screens of information must be accessed to assess these characteristics. On a day of heavy fish passage, a screen of tracked data corresponding to an hour of data collection may contain 1,000 or more tracks that would have to be scrutinized individually by this process in order to remove the tracks corresponding to unwanted targets. Examples of unwanted targets include debris floating downstream, small resident fish or other species moving upstream that are smaller than sockeye salmon, bubbles created by degassing of bottom mud, and noise from the wake of passing boats. Because the approach was not standardized, different TS and trajectory criteria were likely applied to the task of data cleaning, contributing substantially to the resulting variability in passage estimates among permanent staff.

We discussed with the PSC, several ideas for improving their data cleaning, including the use of multivariate techniques such as discriminant function analysis (DFA) to automatically filter and remove tracks corresponding to the unwanted targets. Although the application of multivariate techniques is not possible in the short-term, a TS-filter can be implemented to clean their data and the PSC has agreed to do this. In order to determine appropriate maximum and minimum TS levels, the approach taken is to find a day of heavy fish passage when > 99% of the tracked targets are sockeye salmon and compile a histogram of average track TS, calculate the mean and ± 2 standard deviations, corresponding to the maximum and minimum TS filter limits. Tracks with average TS outside the range encompassed by 2 standard deviations would be deemed unwanted targets and removed from the analytical data set. This level of automation would substantially reduce the workload on PSC permanent staff, although they will be required to check tracks periodically to ensure that the filter is working correctly.

The value of multivariate techniques such as DFA for classifying tracks and identifying targets has been demonstrated in the Wannock River data, where DFA was successfully used to identify and distinguish between milling and actively migrating fish. Multivariate techniques should be able to automate and improve data cleaning because the different classes of targets (e.g., floating debris, actively migrating fish, gas bubbles) that need to be classified typically have substantially different track characteristics. Successful implementation will require a period of data exploration to define and test

appropriate variables and to modify existing software to produce the necessary data for this type of analysis. The HaWG group identified this approach as a medium term strategy to improve data analysis/quality and the PSC will begin developing this technique sometime after the Portland meeting in mid-February 2005 with the help of DFO. The goal is to implement a multivariate tool either in-season during 2005 or during the post-season review of 2005 passage estimates.

The third reliability issue relates to the aiming of the shore-based left-bank split-beam system. The shore-based split-beam system partitions spatial sampling effort using multiple vertical aims of equal duration per hourly interval. Movement of the transducer to pre-determined aiming angles is controlled by a dual-axis rotator and a rotator controller connected to the echosounder. An independent sensor unit (a Jasco system) is attached to the transducer mounting plate to provide information on the aiming angle. The Jasco unit is used prior to data collection to determine the vertical and horizontal values displayed by the rotator that correspond to the true 0° position of the transducer, i.e., when the center of the beam is parallel to the water surface and perpendicular to the flow. These values are used as offset angles by the split-beam system for subsequent aims. During normal data collection operations, the Jasco unit is used to check the real-time aim of the transducer against the pre-determined aiming angles programmed into the software. Thus, the Jasco is a standard check of system operation but it is not essential during routine data collection. In early July PSC staff found that the Jasco equipment at Mission was faulty and borrowed a replacement from the Cultus Lake Lab. The replacement unit apparently sent inaccurate information because the PSC found on Aug 9th that the aims used since July 29th were 3.5° lower than designed, i.e., a design aim of -2° relative to the surface was actually -5.5°. As a consequence, some portion of the water column near the surface was not sampled by the left-bank system during this period. This is potentially important because estimates of fish speed and direction of travel are generated from the left bank and applied to the mobile system data. These estimates may have been biased during this period, as would daily passage estimates derived from the left bank data. The magnitude of this bias is unknown at present.

Discussion of potential remedies for the misaiming focused on best practices at the field site and how to adjust parameter estimates to account for the unsampled portion of the water column. Improved field practices include checking the Jasco unit before deployment to ensure that the signals sent with respect to angle are true, checking the rotators to ensure that they stop and return to the pre-set angles programmed into the controller (PSC field staff currently do this check), and since the transducer mounting plate is accessible at the end of the weir, periodically checking the aiming angle manually with a protractor to confirm the controller settings and Jasco information. Based on several views of the location of all tracked fish, we suggested that when the distribution of tracks from the left-bank system was uniform throughout the portion of the water column sampled, then a linear interpolation to fill in the unsampled area would be acceptable for parameter estimation purposes. On those days when a non-uniform distribution was observed, then average values from the topmost aim should be used to fill in the unsampled area of the water column.

Objective 2: Process to derive final in-season estimates of daily passage at Mission for 2004

The process discussed at these meetings and agreed to by both DFO and the PSC is as follows:

1. Plot a histogram showing the distribution of track average TS for a day of high sockeye abundance. Calculate the mean and use ± 2 standard deviations from the mean as values for the minimum and maximum TS levels for a TS filter.
2. Apply the TS thresholds to data already recleaned by permanent staff (July 1, 10, and 17, Aug 4 and 20, and Sept 6) to assess the impact on variability among individuals (observed to be about 25%). We expect that this variability will be reduced because much of the variability stems from different interpretations of borderline targets and tracks which should be removed by the TS filter. This procedure allows standardization of data removal based on TS.
3. Subsample the left-bank statistics (R_d and speed) to apply to the mobile data. Currently, estimates of R_d and speed from the left-bank are estimated from all of the left-bank aims. However, the downward-looking mobile system has blind zones near the surface (about 1 m) and bottom (about 0.5 m above the bottom) in which targets are not detectable. The left-bank system does not have these blind-zones. The rationale for subsampling the left-bank data is that targets from the top 1-m and bottom 0.5 m should be removed from the dataset before the estimates of R_d and fish speed are compiled for the mobile system because the mobile system will not see these targets.
4. Reclean the data, applying Steps 1-3 above, and re-analyzed to finalize in-season passage estimates. There are approximately 70 days of data so the recleaning and reanalysis will be conducted on every second day of data (35 days in total) and estimates for the other days derived by interpolation.
5. Examine the utility of multivariate analysis to automate some of the cleaning work. This is medium-term strategy and probably won't begin until Steps 1-4 are completed.

We believe that this process will help the PSC meet their goal of finalizing in-season daily passage estimates at Mission in 2004 in time for presentation at the Portland meeting in mid-February.

Gear deployment and operations at Mission in 2004 were consistent with past practices at the site, which were developed jointly by DFO and the PSC. Unusual fish behaviour such as milling or changes in the cross-sectional distribution of migrating fish compared to previous years were not observed in 2004. Furthermore, the impact of aboriginal gillnets on fish distribution was not as prevalent in 2004 as in 2003. Thus, we believe

that the 2004 season was "normal" with respect to the manner in which data were collected at Mission and that resulting passage estimates were probably not biased greatly by unusual fish behaviour, e.g., milling or redistribution related to gill net fishing.

Re-analysis of the hydroacoustic data, as proposed above, will almost certainly alter the final daily in-season passage estimates for 2004. At present we expect that the finalized in-season estimates will be lower than the numbers currently available. However we do not know the magnitude of these changes because some of the operational issues at Mission in 2004 (e.g., absence of sampling in surface waters near the left bank between late July and mid-Aug) negatively bias passage estimates and other issues (e.g., no systematic TS filter) positively bias passage estimates. Based on our discussions with the PSC and our knowledge of the Mission hydroacoustic facility, we believe that the hydroacoustic estimates of in-season sockeye salmon abundance at Mission in 2004 were adequately supporting the in-season management decision-making process. That is, we do not believe that any changes to in-season passage estimates will account for the discrepancy between the estimates of upstream migration at Mission and total spawning ground escapement.

Objective 3: Long-term approaches to improve the Mission estimates

In our response to the PSC memo of 19 Aug 2004, we noted that several of the reliability issues were related to the mobile system. For several years, the HaWG group has repeatedly identified the mobile system as the weakest link in the current system of enumeration at Mission. There are several problems with the mobile system and some such as boat avoidance by fish may not be tractable with current knowledge and techniques. DFO has repeatedly suggested the PSC consider abandoning the mobile system and switch to shore-based systems on both the left and right banks. Several other configurations at Mission and even different sites (e.g., Qualark) have been suggested over the years. Some work has been done on the right bank but no formal assessment of fish passage along this bank is currently available. Costing of different sites has been conducted.

After considerable discussion on the advantages or disadvantages of different configurations/sites etc., we agreed that we needed to devise a work plan outlining the historic data that are available for analysis, additional data/experiments needed to test out ideas, potential configurations/sites, etc. As a first step, we will revisit the long-term planning and subsequent draft document that was begun about 2 years ago but shelved. The idea is to devise a work plan to look at different options to convince ourselves as a group (HaWG) on the strengths and weaknesses of these options before recommending a future course of action. This process will probably begin in 2005, after the Portland meeting in mid-February.

Next Meeting – Nothing formal is scheduled. We have tentatively scheduled a conference call with PSC for 27 Jan 2005 to assess progress with respect to the recleaning and reanalysis of data (Goal 2 above).

To: Fraser River Panel Technical Committee
From: Jim Cave, Mike Lapointe
Date: Thursday, August 19, 2004
Re: Reliability of Split Beam Hydroacoustic estimates in 2004.

During earlier Technical Committee meetings, and at the Fraser River Panel meeting on August 13th, staff noted that there were concerns about the reliability of the split-beam hydroacoustic estimates in 2004. Although staff have been working hard to determine the extent of the problems, a complete evaluation of the 2004 program will not be completed until the post-season. A preliminary assessment of the general concerns that have been identified is outlined below.

1. The inclusion of small non-fish targets in the mobile split-beam data

The threshold setting (i.e., TS threshold) on the mobile split-beam echo sounder was set at -46 db at the start of the season. This setting is 6 db lower than in 2002-3. This decision was based on the lower background noise produced by the this year's low discharge conditions. However, an unintended outcome was an increase in the number of non-fish targets such as bottom features and ambient noise included in the data even after the cleaning stage. The inclusion of non-fish targets in the mobile split-beam data violates the basic assumption that downstream movement in the data are contributed solely from fish targets, whether they be resident or migrating species. These factors resulted in overestimation of the upstream passage of salmon. The Panel was advised of this problem on July 23rd and corrected estimates of upstream passage were provided. These corrected estimates were obtained by filtering out targets in the -40 to -46 db range. We continue to keep the echo sounder's TS threshold set at -46 db and employ a TS filter in the post-processing software to remove targets below -40 db.

2. Manual cleaning of the mobile split-beam data failed to remove non-fish targets

After filtering out the smaller targets, the mobile split-beam target density remained higher than that obtained by the single-beam system. A comparison of the cross-river distribution of mobile single-beam and mobile split-beam targets indicated a difference between the two systems, particularly near the bottom. Staff further investigated the raw and processed data and concluded that the manual process of removing non-fish targets (cleaning the data) during processing of the mobile split-beam data was insufficient, with many non-fish targets being treated as legitimate fish targets. Staff examined the stationary data from the mobile split-beam system, and discovered that for targets greater than -40 db there was a relationship between upstream speed and size of target. Most of the smaller targets (-35 to -40 db) showed downstream orientation and applying downstream statistics from the shore-based system on the south bank did not counteract this bias (i.e., estimates of upstream passage would still be biased high). Additional training of seasonal staff and processing time by permanent staff has greatly improved the quality of the data. However, this is labour intensive and final cleaning of the data will not be completed until the post season.

3. Incorrect aiming from the shore-based split system resulted in incomplete data.

The shore-based split-beam system deployed on the south bank partitions the spatial sampling effort using 7 vertical aims. On July 10th, staff discovered that the Jasco equipment that provides

information on the transducer's aim (orientation in degrees) was faulty and the equipment required repairs. As the river height dropped during July, the south-bank transducer was relocated further out into the river in order to be effective. The Jasco system obtained from the DFO Cultus Lake Lab had been reliable in the past and had performed adequately in calibration tests made on shore. However, when it was deployed, it gave incorrect readings. The most recent redeployment of the apparatus occurred on July 29th, and the incorrect Jasco readings were used to set the aims. Attempts were made to accurately aim the transducer. Staff discovered on August 9th, however, that the vertical aiming angles employed since July 29th were off by 3.5 degrees. Although every attempt was made to generate flux estimates using data from the south-bank system for July 29-August 9, the data were too compromised for this purpose. Also, while flux estimates can be generated entirely from the mobile split-beam system, they depend on direction-of-travel statistics from the south bank system, which failed to sample the upper portion of the water column during these 12 days. Staff are evaluating whether direction of travel statistics from the south bank system can be reliably reconstructed from data collected after August 9th. Split-beam estimates are believed to be biased low for this period. A sensor on the transducer rotator would be invaluable for verifying and monitoring our aiming angles on a continuing basis and we are working towards finding such a solution.

We have examined the effect of these problems on the Mission estimates of daily passage. The current estimates include a combination of single-beam and split-beam measurements (Table 1), with 187,000 Early Stuart, 879,000 Early Summer and 1,068,000 for Summer-run sockeye. Alternatively, if we use the split-beam estimates exclusively (Table 2), the Early Stuart run would be unchanged (187,000), the Early Summer run would be 878,000 and the Summer run would be 1,080,000 fish. Otherwise, if we use the single-beam estimates exclusively (Table 3), the Early Stuart run would be 151,000, the Early Summer run would be 879,000, and the Summer run would be 1,119,000 fish. For the most part, differences between the single and split-beam estimates are small (except for Early Stuart sockeye) and the alternative estimates would have had limited consequences for management decisions. Beginning August 13th, aiming angles and data cleaning have been verified. Thus, in all likelihood, estimates from the split-beam system will be reliable for the remainder of the season. However, if problems reoccur staff will substitute single beam estimates as required.

Summary and Conclusions

Staff will be conducting a full post-season review of the problems with the Mission Hydroacoustic program in 2004. This will include a full summary of events leading up to and during the season, and a full and detailed documentation of the component parts of the program (software, hardware, field deployment, and training) and the possible bias and outcomes associated with these components. We intend to review these findings with the Hydroacoustics Working Group. We will continue to keep the Panel and the Technical Committee fully informed on the progress of this review.

We are disappointed about this turn of events. In the past we have made strong arguments to the Fraser River Panel for the split-beam system as the best available technology to obtain estimates of daily upstream passage of sockeye. In particular, the technology provides for diagnosis of bias and changes in fish behaviour that is unavailable from the single-beam technology that has been in use since 1977. We have learned from the problems encountered in the 2004, however, that real time application of the more sophisticated split-beam technology requires substantial monitoring of the components and data processing to ensure that high quality data are being collected and used for the estimates. We will develop protocols and error checks to prevent problems of this magnitude from reoccurring in the future. Finally, staff remain convinced that the split-beam technology is the best approach for the estimation of daily passage of sockeye at Mission in the future.

**DFO (Riverine Acoustics Group) Response to PSC Memo (19 Aug 2004)
09 Nov 2004**

We have reviewed the information contained in the memo to the Fraser River Panel Technical Committee (Aug 19, 2004) on the reliability of split-beam hydroacoustic estimates in 2004. We offer the following comments in advance of our joint meeting.

1. Inclusion of small non-fish targets in the mobile split-beam data

- Selecting a threshold value is dependent on conditions experienced during the collection period; the threshold should not be a pre-set value, based on the value used in previous years, rather it should be based on conditions present at the time of data collection.
- Minimum threshold values for data collection should be set at the amplitude which removes the background noise level while maintaining the best possible signal-noise-ratio (SNR) for detecting fish. This strategy is designed to allow the optimum number of accepted echoes for a given fish track.
- Elimination of small targets should be done in the post-processing stage by the use of filters. Filters such as target strength (TS) filter would be applied to the average TS obtained by a given trajectory. This method allows for the removal of small fish or unwanted signals that were tracked by the system. Appropriate values for the TS filter may also change from year to year, depending on the size of the targeted fish. Since the mobile system is in a down-looking mode, the TS value for a salmon would be from the dorsal aspect and would indicate a smaller size compared to the same fish in side aspect.

2. Manual cleaning of the mobile split-beam data failed to remove non-fish targets

- A difference between the single-beam and the split-beam mobile systems near the bottom is not unexpected as the single beam has a 0.8ms pulse length compared to a 0.2ms pulse length for the split-beam system. The split-beam system will be able to track fish closer to the bottom.
- Data cleaning appears to be the key issue for the mobile data and unfortunately becoming proficient at editing these data is a long and complex task. Separating legitimate fish tracks from bottom signal or from tracked noise is not always obvious. Data cleaning and associated quality issues will continue to be a concern from year to year because of the turnover in new seasonal staff hired to perform this task as part of their duties.
- Use of a TS filter will not always remove unwanted bottom signal as the received echo from a bottom signal may indicate a larger size and would not be eliminated by a TS filter which removes smaller amplitude echoes. Swim speed, an effective tool in removing unwanted tracks on the shore based system, can not be used for the mobile data. This will put a greater demand on ensuring each data file is fully edited.
- We note that two of the three issues identified in the Fraser Panel memo are related to the mobile system. Every year during our joint discussions of the Mission hydroacoustic facility, the mobile system is consistently identified as the

main weak link. Many of the technical issues that we continue to debate are related to the mobile system and are well known, including boat avoidance behaviour, the necessity of running the mobile system continuously because it samples only a small area of the river cross-section during each pass from bank-to-bank, blind zones near the surface and bottom and the effects of fish behaviour, especially milling which cannot be detected by the downward looking system, on the mobile data. Solutions or corrections are not so well known and in some cases such as bias introduced by boat avoidance it likely will be impossible to remove from the flux estimates. These concerns will continue to affect the upstream flux estimates at Mission as long as the mobile system is used.

- Perhaps the time has come to consider the advantages/disadvantages of alternative operating modes at Mission. We are all aware of its complexity. Should the mobile system continue into the future? Should the number of transects be reduced? Would it be better to use a right bank shore-based system along with the present shore-based system and extrapolate for the middle section?

3. Incorrect aiming from the shore-based system resulted in incomplete data

- Movement of the transducer to pre-determined angles is done by the rotator and rotator controller, which are independent of the Jasco system. Regardless of whether the Jasco unit works or not, the rotator sets individual aim locations and governs the repeatability of subsequent aims. Since the left bank system is deployed from a fixed weir with the transducer-aiming-unit attached, the use of a separate position sensor is not a paramount operational requirement. The Jasco sensor was needed when deploying the transducers from a tripod that was placed on uneven bottom contours or when the tripod was not visible from the surface.
- Function of the rotator should be checked prior to the data collection period to ensure that it physically moves the number of degrees intended. Periodic checks of rotator function should then be done during the data collection period. This can be accomplished by attaching a magnetic protractor to a bracket that is above water to indicate the exact position the transducer.
- We are unsure why the data from July 29-August 9 period are completely unusable for upstream flux estimates. Even if the aims were off by 3.5° (we are assuming that the error was -3.5°) some portion of the upper water column would be sampled by the $4 \times 10^\circ$ transducer in the uppermost aims and could be used for direction of travel. Since attainable ranges are interpreted by monitoring the return signal off the oscilloscope, there should not be any effect on the lower aims other than being shorter than anticipated due to the angle being lower than expected. The resulting flux numbers probably underestimate the true upstream flux along the left bank, but this would seem to be a better approach than discarding the data entirely.
- We suggest that reliance on single-beam estimates of upstream flux is not wise considering the known technical problems associated with single-beam data collection and analysis. We reiterate that in our opinion the side-looking split-

Attachment #2

beam system on the left bank is the best available approach for estimating daily upstream passage of salmon at Mission and we suggest that a side-looking split-beam system should be established on the right bank as soon as practicable.

- We agree with the suggestion that ongoing monitoring of system operation and data analysis is needed and that system operation and error checking protocols will be established based on experience in 2004.