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Subject / Object **RIVERS INLET SEASON SUMMARY 2003 - HYDROACOUSTIC FEASIBILITY STUDIES**

Summary Report to the Rivers and Smiths Restoration Society and DFO Central Coast Fisheries Management

The conclusions from the 2002 Wannock River feasibility study were:

Positives:

- Good acoustic fish detection.
- Good river coverage, expansion factors can be calculated for the areas not covered by the acoustic beams if needed.
- Good species separation, the food fishery located below the acoustic site could give species composition.
- Fish densities well within workable ranges.
- Relatively short migration season.

Negatives:

- Unusual fish behaviour, milling in fast current.
- Need to separate milling fish from the actively migrating fish for flux estimation (estimate of salmon passage per unit time).
- Suitable acoustic sites are limited on this river.
- Requires two acoustic systems to cover the river cross-section.

Our first field season (2002) on the Wannock River (Cronkite et al 2003) demonstrated that milling fish were a problem for hydroacoustic estimates of upstream flux because there are a limited number of suitable acoustic sites. During the winter of 2002-2003 we used Discriminant Function Analysis (DFA) to develop a tool that categorises fish tracks (upstream, downstream, milling) based on the swimming behaviour of fish so that we could separate migrating fish from milling fish. When tested against the judgement of a trained acoustician, the resulting discriminant function classification was consistent on 98% of the tracked fish for the 2002 right-bank data from the Wannock River. During the 2003 field season this same right-bank DF did not perform well for the left-bank data, but post-season optimisation of the DF gave approximately 92% agreement. We believe that the DF is a flexible tool for categorising tracked fish that can be optimised for different acoustic sites where the migratory behaviour may differ. On a side note, the DF also proved useful for removal of acoustic noise from the data, allowing the exclusion of interference noise data.

Once fish are classified by the DF and milling fish are filtered from the acoustic dataset, we can estimate the net upstream flux, which would give us the minimum number of fish actively migrating to the spawning grounds. However, fisheries management needs to consider the benefits and costs of estimating the additional spawning ground escapement represented by milling fish. If an absolute estimate of the total number of milling fish is needed, then an area-under-the-curve (AUC) approach could be used. The first step is to count the milling fish periodically, which we believe can be achieved using distance sampling (Buckland et al. 1999), which includes both line and point transect methods. The next step is to determine the average length of time a fish is milling over the course of the migration. This is a difficult question to address, as it requires following many fish for extended periods of time. One way to look at this problem is with tagging studies, but these are expensive in terms of personnel and tags needed to collect reliable data. Also, tagging would likely need to be done every season as the behaviour of the milling fish may change (e.g. in 2002 the run lasted approximately 10 days and in 2003, 25 days, although the runs were similar in size). Also, there is the reoccurring question of whether the behaviour of tagged fish is representative of milling fish behaviour. These problems may make tagging unfeasible on an ongoing basis, but a one-time-only tagging project could add to our knowledge of the mechanics of the milling behaviour.

Without the needed information on the milling fish, the best estimate can be achieved by counting the migrating fish, giving a minimum net flux which could also be thought of as an index of the run size for management purposes. This is our current approach, which assumes that interannual variability in the proportion of fish milling is negligible compared to annual variability in total migration returns. A total population estimate would require the assumption that the milling fish eventually begin active migration below the acoustic site. We also assume that milling fish behaviour (not the length of time they mill, which we have seen does change) will not change significantly from season to season and therefore, that the counts each season will be comparable. Again, tagging studies could indicate if these assumptions are realistic.

Results and Discussions

Wannock River

We covered approximately 75% of the river cross-section with the acoustic beams at the Wannock River acoustic site (Figure 1). The areas not covered by the beams were inshore of the transducers and in the deepest part of the channel. We looked at the inshore areas and concluded that fish passage in these areas was probably insignificant. In the deep channel area, fish detection is limited by acoustic noise in the water column, which may be an indication of bedload silt and/or debris or turbulence forming small bubbles. We feel that it is unlikely that significant numbers of fish migrate through this area for physiological reasons (fish avoid dense silt flows). Also, plots of the vertical distribution of migrating fish indicate that fish density decreases with depth, with most of the passage occurring in the top 4 metres of the water column.

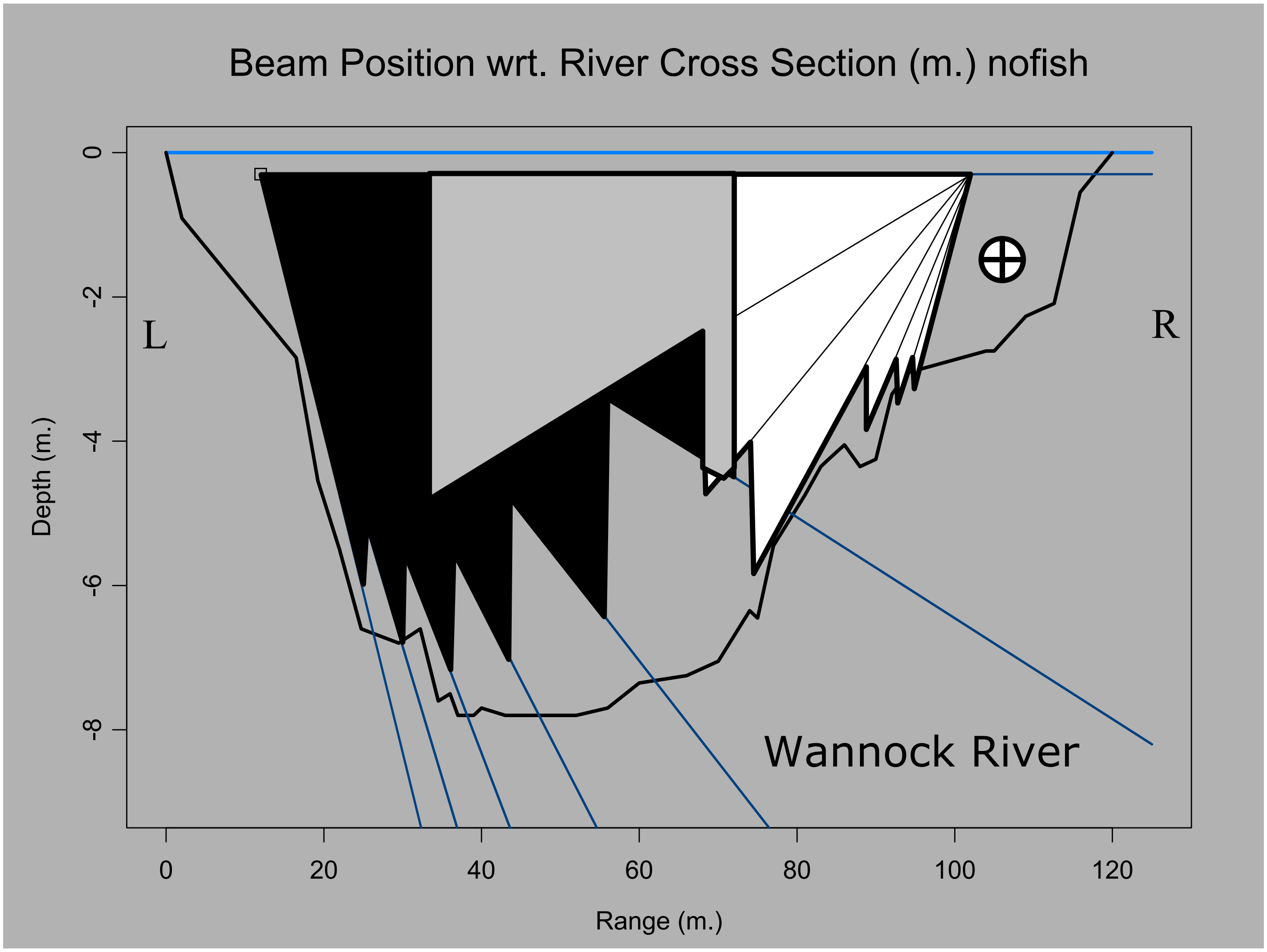

Figure 1. Wannock River acoustic site bottom profile showing the coverage of the acoustic beams. The blue line at 0 m depth represents the water surface and the black line represents the river substrate. The beams are outlined by the radiating lines from the transducer positions near the river banks. The area covered by the left-bank system is indicated in black and the area covered by the right-bank system is indicated in white. The grey area represents the overlapping coverage by the two acoustic systems. This view is looking downstream from the hydroacoustic site, with water moving into the page as indicated by the circle with the cross. Right- (R) and left-banks (L) are named by convention when the observer is looking downstream.

We operated two acoustic systems on the Wannock River in 2003 (left- and right-bank sites) and collected data out to 60 to 70 m range. There was approximately 100 m between the two transducers. We found that the best balance between the two systems was left-bank 55 m range and the right-bank 45 m range. This allowed us to maximise the coverage area and avoid acoustic noise that is common in the longer-range data. This balance between the systems also avoided the double counting of fish in the areas of overlapping coverage.

Figure 2 displays the Wannock River run timing curve for 2002 based on right-bank data. The upstream and net flux curves are similar, as there were few downstream migrants at the right-bank site. The left-bank was tested near the end of the sockeye season in 2002 and therefore left-bank data for the complete season is not available. The index count was 174,496 from the right-bank data. The left-bank accounted for 39.5% of the net flux in 2003 and therefore we used this value to roughly estimate the net flux in 2002 (assuming similar fish behaviour between the years), arriving at an estimate of 243,422 fish. This number contains an unknown proportion of species other than sockeye, as test fishing for species composition was not conducted in 2002.

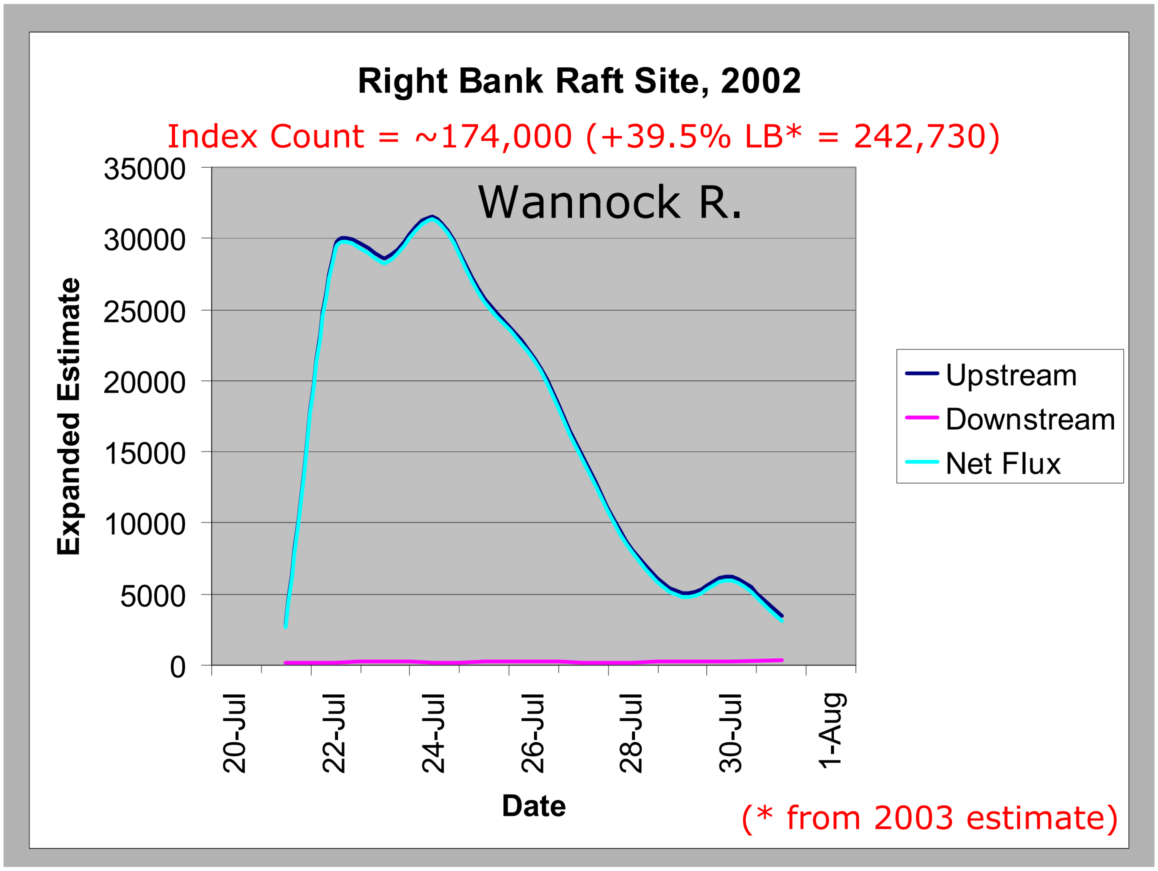

Figure 2. Wannock River run timing curve for the 2002 sockeye season. Only right-bank data were available for the entire season. There was very little downstream migration on the right-bank at this site as displayed by the purple line. Expansions were made using the proportion of fish travelling up the left-bank for the 2003 season to roughly estimate the total flux for 2002. The run spanned a time period of approximately 10 days. These data were filtered with the DF to remove milling fish.

Figure 3 presents the run timing curve for 2003 with an index count of 340,006 fish past the acoustic site. As in 2002, this estimate contains an unknown proportion of non-sockeye species, emphasising the need for test fishing to estimate species composition. Chum and Pink salmon were noted spawning around the mouth of Medowse Creek above the acoustic site on August 10, 2003 and likely were beginning to spawn before this time. Some schooling behaviour was noted on the real-time echograms as data was being collected on August 5. This type of schooling behaviour is associated with pink salmon passage on rivers such as the Fraser River (Xie et al, 1997).

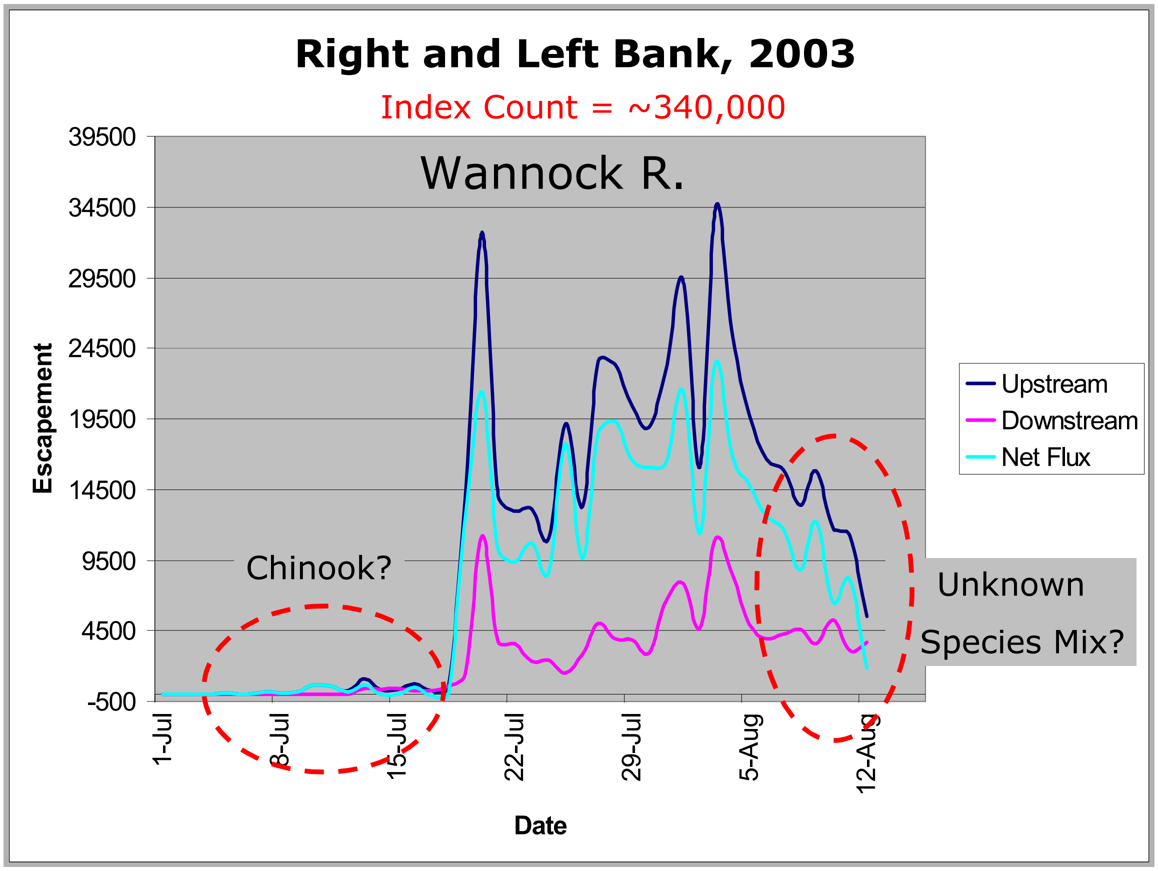

Figure 3. Wannock River run timing curve for the 2003 sockeye season for right- and left-banks combined. Most of the downstream counts occurred on the left-bank. The run spanned a time period of approximately 21 days. The horizontal ellipse indicates the period of suspected chinook salmon migration and the vertical ellipse indicates the period when an unknown mix of species other than sockeye were suspected migrants. The counts shown are for actively migrating fish – milling fish were filtered from the dataset using the optimised right-bank DF developed in 2002 and optimised left-bank DF developed in 2003.

First Narrows

A cross-section of the First Narrows acoustic site is shown in Figure 4. The area on the left of the plot from 0 to 50 m range was surveyed but few fish appeared to move through this area. The top 2 aims could be extended to meet the far shore during periods of calm, but the 100 m range shown was reached as a compromise to minimise noise in the data. This site proved to be acoustically noisy from daily winds, rain and masses of wood debris (Figure 5).

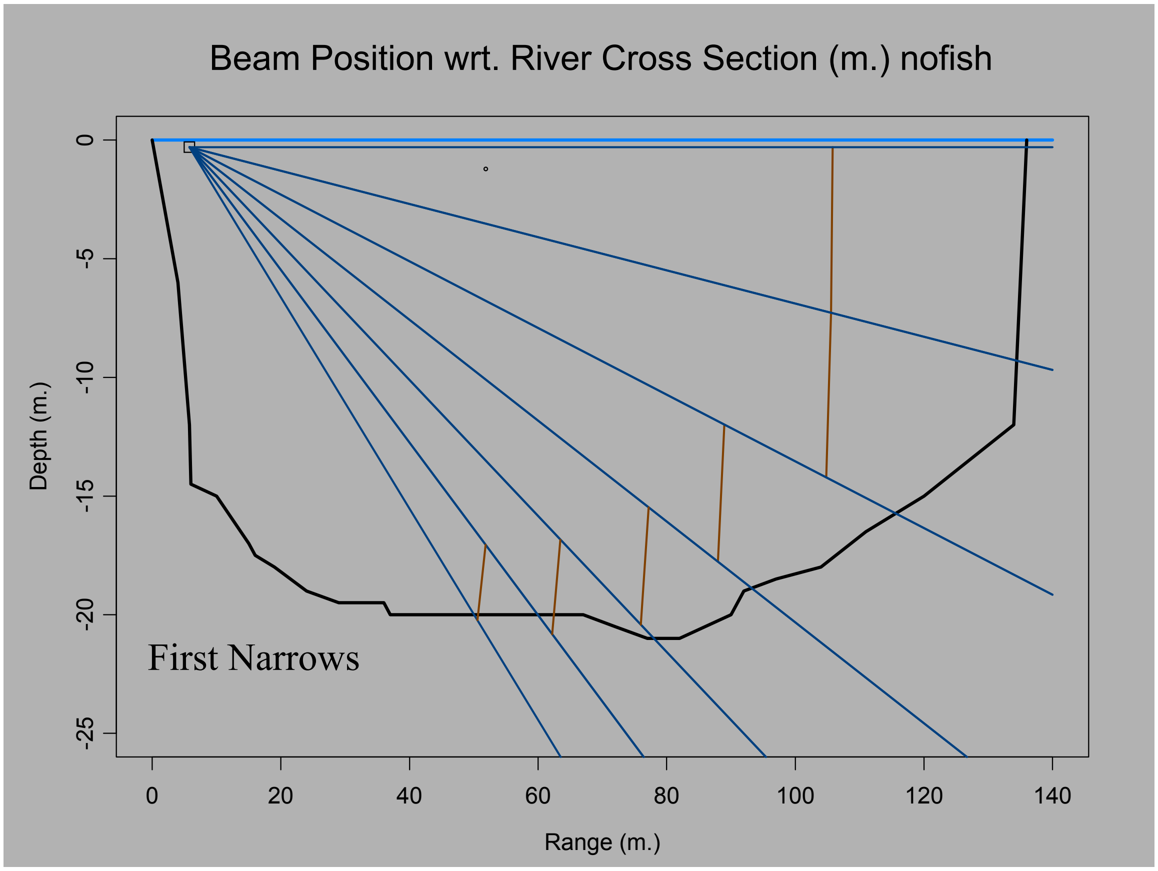

Figure 4. First Narrows acoustic site profile with acoustic beam coverage shown by the radiating dark blue lines. The brown lines show the maximum ranges used for data collection. The blue line at 0 m depth represents the water surface and the thick black line represents the substrate.

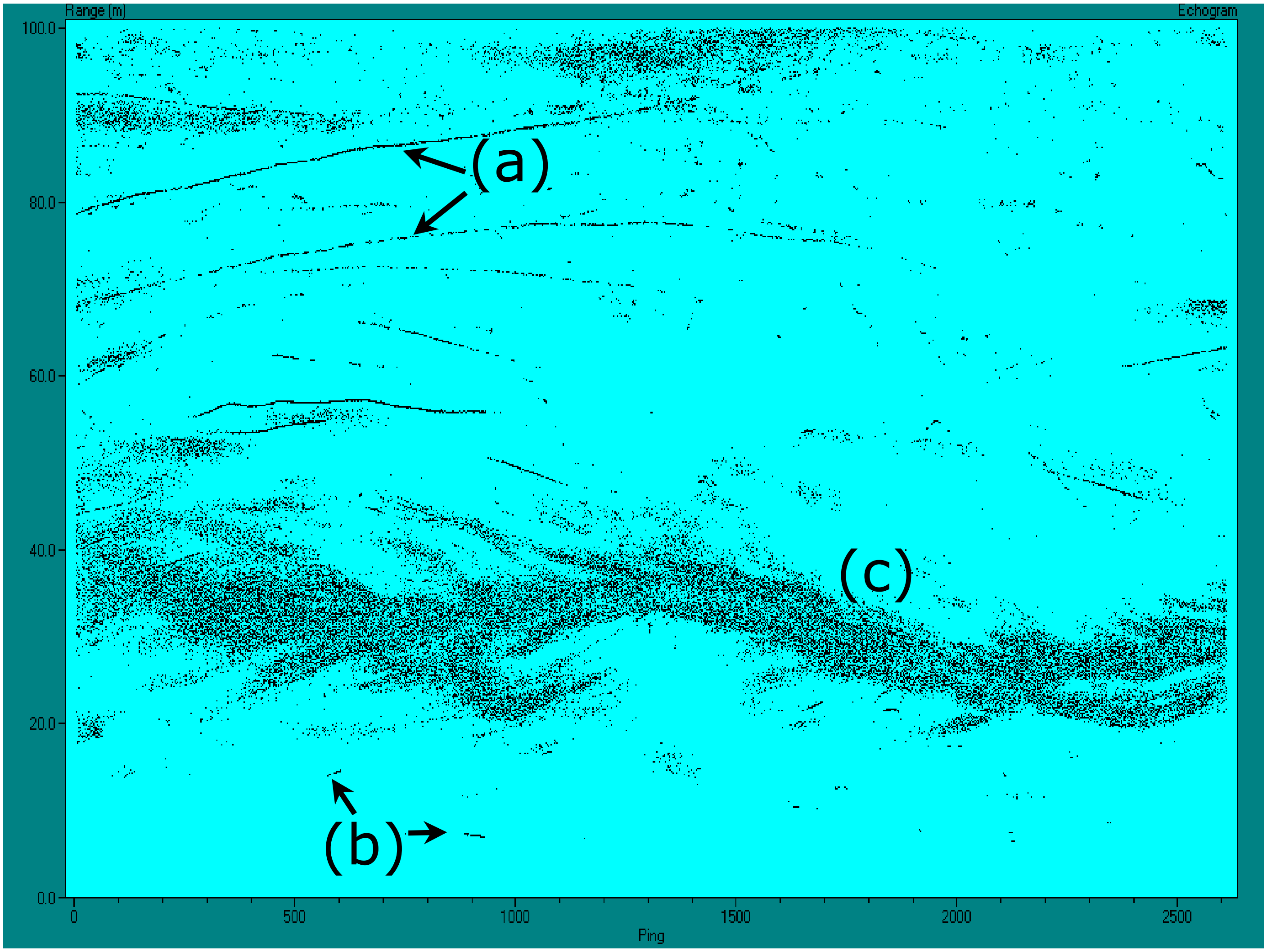

Figure 5. Echogram from the First Narrows acoustic site for the top aim, which is parallel to the water surface. The extended tracks (a) are from slow moving log debris while the short tracks (b) are mostly from migrating fish. The extensive patterns of black dots (c) are from wind-driven surface noise.

The large quantities of debris moving downstream with the current and upstream with the wind proved to be a large problem at the First Narrows site. Sometimes conditions were such that the debris traveled in both directions simultaneously. Often the same pieces of debris could be visually observed for several days at a time. However, because the debris moved very slowly relative to the fish in the area, we were able to separate the fish tracks from the debris tracks with the use of a speed filter. Preliminary results show that roughly equal proportions of fish were detected travelling both up- and downstream past this site. This finding is not surprising considering that the site is located at a narrowing between two lakes, upstream of, and in close proximity to, the Neechanz and Machmell river mouths. Also, a spawning channel fed by Machmell River water is located just upstream of the acoustic site. This situation may be causing both upstream and downstream movement of fish as they search for appropriate attraction flows.

Originally we planned to determine if the Shemahant River was suitable for acoustic enumeration in 2003. The Shemahant River was surveyed in May 2003 and the only suitable site was located near the mouth of the river. Discharge rates in May were low and when the river was visited in August the water levels were much higher, but normal for the time of year. However, it was not possible to tow the log float up the river to deploy the system due to strong currents and approximately 1 m high standing waves near the river mouth.

An alternative was to deploy the acoustic system from shore, but the higher water levels were causing turbulent flows and large debris entrainment. The shore site would have been acoustically noisy and dangerous to both equipment and personnel. Heavy rains later in the spawning season caused water levels to advance well back into the trees and caused extensive large debris passage. In short, this volatile glacial river is not suitable for acoustic enumeration of salmon.

At the time of this writing, the First Narrows dataset has not been completely analysed due to time constraints. There is a need to further develop and test software routines to separate debris tracks from fish tracks. We also need to examine the data in more detail to determine the magnitude of milling behaviour at this site and to assess the feasibility of achieving a flux estimate. Preliminary indications are that milling behaviour at the First Narrows site is too extensive to allow a count to be obtained. Furthermore, under ideal circumstances, two acoustic systems are needed to cover both banks, reducing noise in the data by allowing shorter processing ranges to be used. However, the right-bank is exposed to wind/wave action and a log raft on that bank would need a breakwater to reduce transducer movement and prevent raft damage. More work on the data is needed to make a definitive conclusion, but our preliminary conclusion is that this is not a desirable acoustic site.

Third Narrows

Figure 6 presents the side-view of the Third Narrows acoustic site. Each point represents the mean position of a tracked fish that passed the site on August 20, 2003. We note the large proportion of milling fish and the near equal numbers of upstream and downstream migrating fish. This site showed extreme milling behaviour.

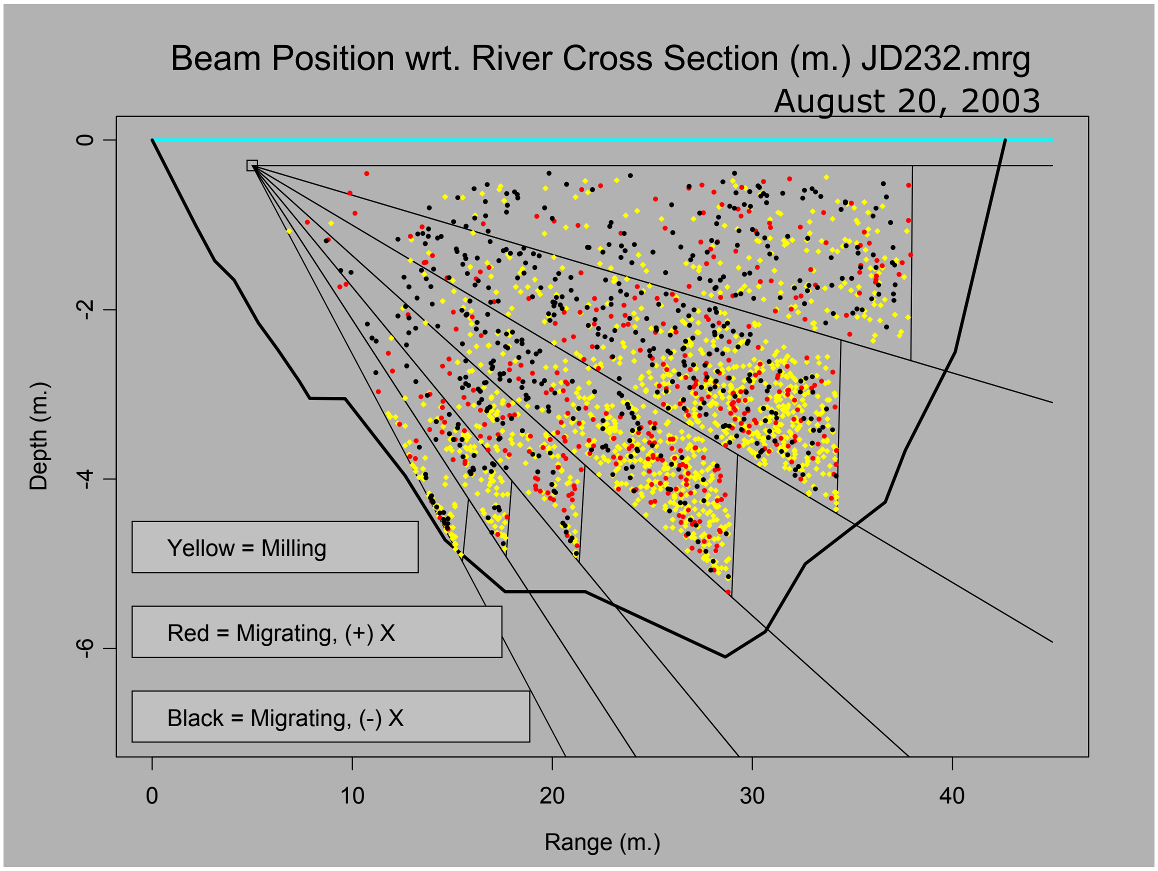

Figure 6. Third Narrows acoustic site profile with acoustic beam coverage shown by the radiating black lines. The vertical lines show the maximum ranges used for data collection. The blue line at 0 m depth represents the water surface and the thick black line represents the substrate. Each point represents the mean position of a fish as it was tracked through the beam. The yellow points represent milling fish, the red points represent downstream migrating fish (+X direction) and the black points represent upstream migrating fish (-X direction).

Figure 7 presents the run timing curves for the data collected at the Third Narrows site and shows that there is a very high proportion of downstream migrating fish compared to other sites (e.g., Figures 2 & 3), which results in a net flux estimate of –381 fish. The DF developed for this site demonstrated approximately 92% agreement with a trained acoustician and the results showed a nearly equal upstream and downstream movement over the season. Based on these data, we believe that the fish are moving freely back and forth between the two lakes and some fish may be dropping back after spawning. In addition, chum, coho, sockeye, pink and resident species including rainbow trout and dolly varden char were noted at the site. The chum, pinks and some sockeye salmon were actively spawning at the mouth of the creek just downstream of the acoustic site. We conclude that this site is not useful for measuring fish flux hydroacoustically.

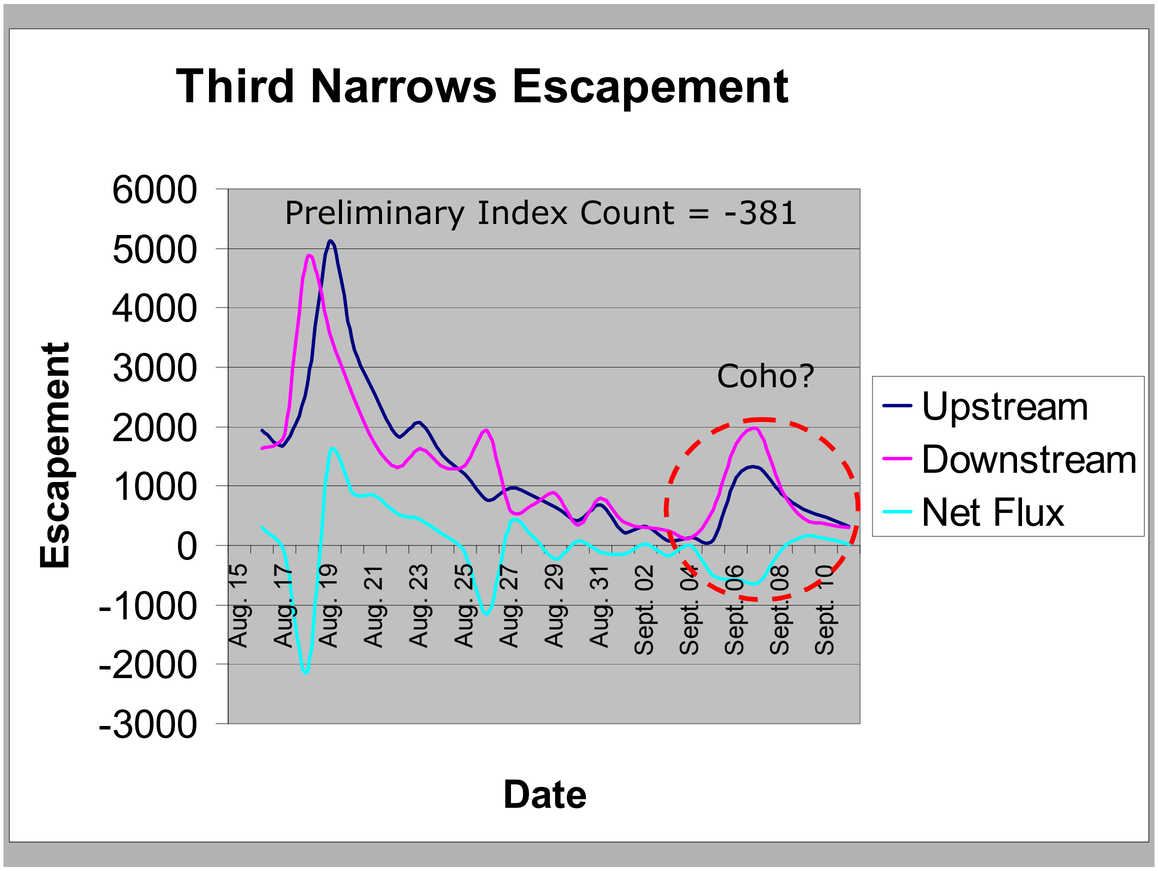

Figure 7. Third Narrows run timing curve for the 2003 sockeye season. The dashed red ellipse indicates the period of suspected coho salmon migration.

Once we became aware of the multiple species present at the Third Narrows site, we decided to measure the in-situ target strength (TS) of various live salmon species at the site. TS is a measure of the acoustic energy reflected back to the transducer by a fish and may be helpful in identifying species, especially if these species differ in size. The results of the experiment are presented in Figures 8 and 9. The TS distributions for fish of greatly differing sizes are similar and the mean TS values are quite similar. Based on these data, a 51 cm long pink salmon was indistinguishable from an 82 cm chum salmon. Additionally, all the mean TS values were much smaller than those measured in the Wannock River during the sockeye migration in 2002 and 2003. We hypothesise that this difference in TS values between the Third Narrows and Wannock River acoustic sites was because the Third Narrows fish were post-spawners and as a result the body condition had degenerated, with higher water content in their flesh (low lipid) and possibly reduced swim bladder volumes. By contrast, the Wannock River fish were just beginning the freshwater phase of their migration.

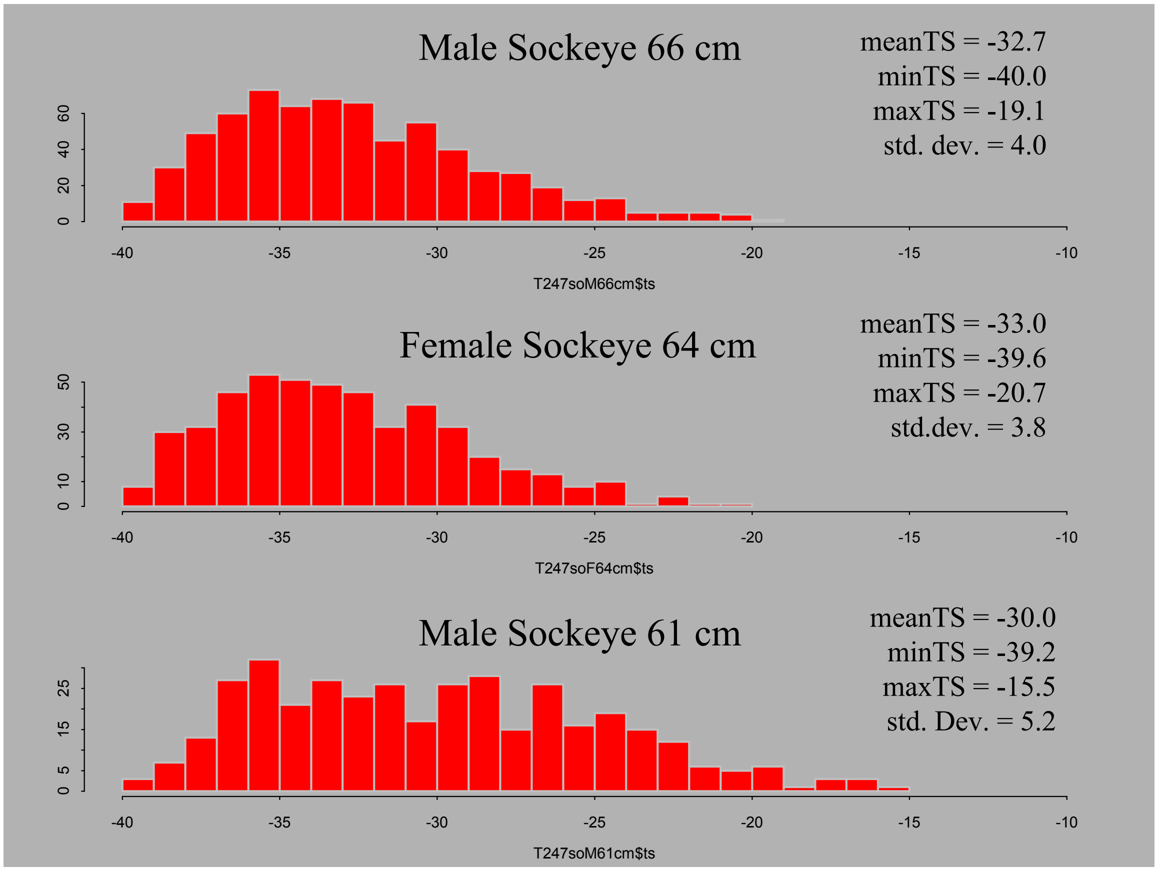

Figure 8. Target strength distributions for three sockeye salmon. Sizes are fork lengths. The fish were tethered and coaxed to swim randomly through the acoustic beam to derive target strength distributions for multiple fish orientations. The mean, minimum, maximum and standard deviations of the target strengths are listed.

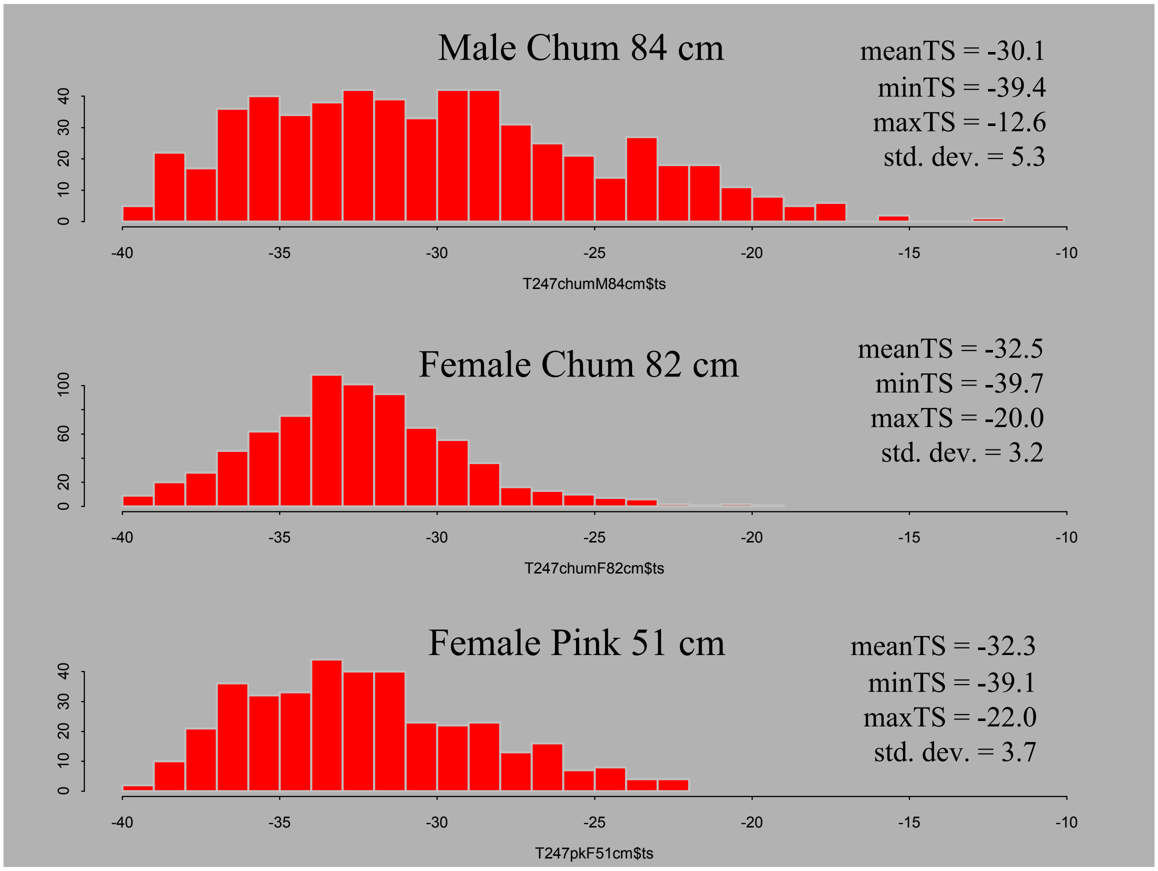

Figure 9. Target strength distributions for two chum and one pink salmon. Sizes are fork lengths. See the figure 8 caption for a complete description.

Overall Conclusions

We feel that the feasibility work performed in the Rivers Inlet drainage basin has been successful in identifying/accepting/rejecting split-beam acoustic sites for salmon enumeration. The work has also been successful in developing the methodologies needed at the Wannock River acoustic site to produce estimates of minimum salmon flux. Based on our experience in 2002 and 2003, we recommend focusing on the Wannock River hydroacoustic site for in-season run size estimation of sockeye salmon, bearing in mind the problems with the milling fish at this site. We emphasize the need for the Rivers and Smiths Restoration Society and DFO fisheries managers to develop a complete understanding of the ramifications of the salmon milling behaviour at the Wannock River site and the effect of this milling on estimates of salmon flux. We believe that we have demonstrated the feasibility of using two hydroacoustic systems to derive minimum estimates of actively migrating salmon escapement into Owikeno Lake. The Rivers and Smith Restoration Society and DFO Central Coast fisheries managers now need to decide if an annual hydroacoustic program will be initiated to monitor sockeye salmon escapement. If a decision to proceed with a hydroacoustic program is the result, then discussions need to begin as to technology transfer and acoustic equipment purchases. At least two personnel will need extensive acoustic training to operate this site in the future and a third will need training in the data cleaning methods. The Department of Fisheries and Ocean's Applied Technologies Section is a research and development group and therefore does not do long-term monitoring of fish stocks. However, we would like to be involved with the Rivers Inlet work on a consultative/mentoring basis to maintain scientific reliability and continue with research and development. Obtaining better estimates of additional escapement due to milling fish is an important scientific issue and a question that we are interested in pursuing. Whether these data are necessary for management purposes is a question that the Rivers and Smith Restoration Society and DFO Central Coast fisheries managers need to address after carefully considering the cost-benefit of obtaining these additional data on an annual basis.

References

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