EVALUATION OF HYDROACOUSTIC SITE ON THE YUKON RIVER TO MONITOR PASSAGE OF SALMON ACROSS THE US/CANADA BORDER, 2003

By

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REGIONAL INFORMATION REQPORT[1] NO.3A04-18

Alaska Department of Fish and Game
Commercial Fisheries Division
AYK Region
333 Raspberry Road
Anchorage, Alaska 99518

March 2004

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ACKNOWLEDGMENTS

We would like to acknowledge Andy Bassich for the use of his boat and his time spent helping us collect the transects. Roger Dunbar of ADF&G and Randy Brown of the United States Fish and Wildlife Service (USF&W) provided consultation regarding potential sites along the river. Dave Daum (USF&W) provided information about the previous study near Eagle. Finally, we acknowledge John Hilsinger and Susan McNeil for reviewing this manuscript.

PROJECT SPONSORSHIP

This project was supported by U.S./Canada treaty implementation funds administered by the US Fish and Wildlife Service, Agreement #70181-3-G223 (Eagle Site Sonar).

OFFICE OF EQUAL OPPORTUNITY (OEO) STATEMENT

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ABSTRACT

A set of 21 transects was collected near the village of Eagle, Alaska on August 5, 2003 in an attempt to find a suitable location to eventually deploy sonar to count migrating salmon. The site with the greatest potential was located just downriver of Calico Bluff (N64° 55.870' W141° 10.374'). The river bottom at this site was linear on both banks with a substrate consisting relatively of small cobble. The profile and bottom substrate at this location should be conducive to counting salmon and to allow full river coverage with sonar. Further investigations should focus on determining the spatial distribution of fish passing the site and the relative contribution of resident species to the total count.

KEY WORDS: salmon, sonar, hydroacoustic, global positioning system, Eagle, Yukon River

INTRODUCTION

The Yukon River flows over 1,700 miles through Alaska and Canada. Commercial and subsistence fisheries harvest salmon throughout most of the drainage. These salmon fisheries are critical to the way of life and economy of people in dozens of communities along the river, in many instances providing the largest single source of food or income. Management of the fisheries on this river is complex and difficult because of the number, diversity, and geographic range of fish stocks and user groups. Information upon which to base management decisions come from several sources, each of which has unique strengths and weaknesses. Gillnet test fisheries near the mouth provide inseason indices of run-strength, but interpretation of these data is confounded by gillnet selectivity and changes in net site characteristics. Also, the functional relationship between test-fishery catches and abundance is unknown. Mark-recapture projects provide estimates of total abundance, but the information is typically not timely enough to make day-to-day management decisions.

Further exacerbating the need for accurate abundance estimates are recent US/Canada treaty agreements that specify numbers of chinook and chum salmon that must be passed into Canada. Accurate abundance estimates not only help managers adjust harvest in season, they are also used post season to determine whether treaty obligations were met.

In 1992, a project was initiated near the village of Eagle, Alaska to examine the feasibility of using split-beam sonar to estimate the number of salmon migrating across the US/Canada border (Johnston et al. 1993, Konte et al. 1996). This project was the first documented use of split-beam sonar in a riverine environment, and over the three-year duration of the study a number of problems were identified. Phase corruption was observed and was likely exacerbated by the highly reflective bottom (Konte et al. 1996). The errors in the phase measurement were believed to have resulted in overly restrictive echo angle thresholds. Echoes from fish that were physically within accepted detection regions were automatically removed from the data files because of errors in angle measurement. Other equipment issues reflected the early state of development of the new equipment, most of which have since been addressed.

The first of a number of recommendations from the previous studies was to find a better site with smaller rocks and a smoother bottom profile (Johnston et al. 1993). The large rocks may have further compromised fish detection by limiting how close to the bottom the beam could be aimed. Secondly, reverberation from the large rocks may have caused phase perturbation increasing errors in position measurements. Thirdly, the uneven bottom (Figure 1) may have allowed fish to pass undetected by the sonar, and a more linear profile would alleviate this problem and allow detection of fish at longer ranges. Sampling longer ranges at the 1992 project site would have required additional equipment, increasing the complexity and expense of the project (Johnston et al. 1993).

Additionally, it was thought the project would benefit by gaining a better understanding of behavior and spatial distribution of the fish passing the Eagle site. Gillnets were used to look at species composition but drifting was deemed too difficult because of high water velocities.

Consequently, set gillnets were deployed downstream of the site with a recommendation to deploy set gillnets upstream of the sonar in the future. The last recommendation was a wide variety of mesh sizes should be used to obtain a less biased sample of all species present (Johnston et al. 1993).

The objective of this study was to identify a suitable location on the Yukon River to deploy hydroacoustic equipment to detect chinook and fall chum salmon migrating into Canada. Considering the recommendations of past work, criterion for a suitable site was linear bottom profiles on both sides of the river without large, angular rocks that can make fish detection problematic.

METHODS

Bottom profiles were collected with a Lowrance X-15 fathometer[2] with attached Global Position System (GPS). The GPS was able to obtain a Wide Area Augmentation System (WAAS) signal to enhance the resolution of the position measurements. Typical WAAS correction allows position measurements accurate to within 3 meters 95% of the time. For each transect, an attempt was made to keep ground velocity constant and the path straight. Constant velocity was not a requirement since the paired depth and positional information allowed for uneven boat velocity, but does help when viewing the uncorrected transect images in the field. Transects were taken starting at White Rock in Canada proceeding downriver to a sandbar below Calico Bluff in Alaska (Figure 2).

RESULTS

A total of 21 transects (not including aborted attempts) was completed on August 5, 2003 (Table 1, Appendix A). Of these transects, two sites were noted as having the greatest potential for sonar deployment. Charts 26, 27 and 28 were taken near Shade Creek and show a linear bottom on each side of the river (Appendix A). Chart 32 taken just down from Calico Bluff also had a linear bottom profile with the advantage the substrate on this bank appeared to consist of smaller cobble than was observed near Shade Creek. The site with the most potential on the Canadian side of the border appeared to be the location of Chart 16. Chart 16 displayed a linear profile, however, the presence of a small channel on the south bank of the river, as evidenced in Chart 17, presents a significant challenge to any potential full river sampling at this site.

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[2] Mention of a company's name does not constitute endorsement by ADF&G.

DISCUSSION

The site with the apparent greatest potential to successfully detect migrating salmon is just downstream from Calico Bluff (13 miles downriver of the village of Eagle). The bank profile there is linear outward from each bank with a slight flat spot in the thalweg. It should be possible to ensonify the full width of the river from the banks at this site using split-beam sonar on the left (west) bank and a long range DIDSON (new imaging sonar) on the right (east) bank (Figure 3). Full river coverage would also be possible near Shade Creek using the same equipment. The advantage of the Calico Bluff location is the river substrate appeared to be composed of smaller rocks than at Shade Creek. This appearance was inferred from the size of exposed rocks near the waterline although it is possible that substrate composition further from shore may differ. The less reflective substrate will make possible aiming the sonar beam close to the bottom to result in better fish detection, which showed a strong tendency to bottom orientation in the previous study.

The site in Canada with the best profile (Appendix A, Chart 16) has potential, but the presence of the small channel on the side opposite an island could be problematic. Even during the low water experienced during this study, the secondary channel had flowing water (Appendix A, Chart 17). Although a weir could prevent fish from utilizing this channel at low water, to completely block the channel during periods of normal or high water may be impossible (or impractical).

The next step in project development will be to determine the spatial fish distribution and the relative contribution of non-salmon species at the new site. Spatial distribution will ultimately dictate equipment selection. If the relative abundance of other species is sufficiently high, the project leader will ultimately have to consider methods of species apportionment such as those employed at the ADF&G sonar project near Pilot Station, AK (Pfisterer 2002).

To the extent possible, we will investigate the feasibility of utilizing the DIDSON sonar at the chosen site. The DIDSON is an imaging sonar that was developed by the University of Washington's Applied Physics Laboratory (APL) to aid the military in detecting submerged explosives (Belcher *personal communication*). During the summer of 2002, the Department contracted APL to test the DIDSON in Alaskan rivers. In attendance were numerous sonar experts and users including Tim Mulligan, formerly of the Department of Ocean and Fisheries, Canada; Debby Burwen, ADF&G Sonar Biologist; Nancy Gove, ADF&G Biometrician; Don Degan of Aqacoustics; Anna-Marie Mueller of Aquacoustics; Ted Otis, ADF&G Fishery Biologist; Lee McKinley, ADF&G Fishery Biologist; Dan Huttunen, ADF&G Sonar Biologist; and Suzanne Maxwell, ADF&G Sonar Biologist. The researchers thought the DIDSON was easy to use and not subject to many of the limitations of other sonar devices. With the DIDSON it was possible to count fish at high densities, easily determine direction of travel, and obtain body length information on targets. At the same time, the equipment was easy to operate, and the software was user friendly and robust (Maxwell 2002).

The Department purchased a DIDSON sonar for the Aniak River in 2003 to begin the process of transitioning this project to the newer equipment. As part of the transition, the DIDSON was operated simultaneously and adjacent to the existing dual-beam system for approximately three weeks to compare passage estimates resulting from the two systems (Sandall *In press*). Preliminary results indicate the DIDSON better distinguishes individual fish at high densities and the effect is a density-dependent, negative bias of the dual-beam passage estimates (Figure 4).

Given these experiences, we think the DIDSON will enable the Yukon project to obtain the best estimates possible at the same time providing ease of use not available with any other system. The primary limitation of this system is the maximum range is limited to about 60 m. Full river coverage with this system would be at the least impractical, if not impossible to obtain. If chinook and chum salmon are found to be predominately bank oriented at this site, it may be possible to count the majority of the fish using one DIDSON on each bank while sampling the middle of the channel using split-beam equipment. Another possible sampling scenario, would be to use split-beam sonar on the left (west) bank, and DIDSON on the right (east) bank, as depicted in Figure 3. The appropriate sampling approach will be made once more is known about the spatial distribution of fish passing the site.

In summary, we were encouraged by the bottom profiles obtained by this study. Two potential locations for sonar deployment were both downstream of Eagle, AK. The preferred site was located near Calico Bluff. The profile at this location was linear over most of the channel and from what we could see of the substrate, should allow good detection of fish with minimal bottom interference. Given the width of the river and the profile of the bottom, it may well be possible to obtain full river coverage using a single sonar on each bank. Therefore, coupled with the apparent stability of this site, we think further research into its potential use as an acoustic-based salmon passage assessment project location is warranted.

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Maxwell, S. 2002. The feasibility of estimating migrating salmon in turbid rivers using a dual frequency identification sonar (DIDSON). Presentation at the American Fisheries Society meeting, Girdwood, AK.

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Table 1. Locations and notes from transects taken near Eagle, Alaska, 2003.

Transect Name	Description	GPS Location	Comments
Chart 10	At White Rock	N64° 37.715' W140° 52.501'	Aborted
Chart 11	At White Rock	N64° 37.715' W140° 52.501'	Mid-River towards shore (fishwheel)
Chart 12	At White Rock	N64° 37.715' W140° 52.501'	Shore-to-shore from fishwheel. Lost bottom when got near island
Chart 13	At White Rock	N64° 37.715' W140° 52.501'	Shore-to-shore, south bank ->north bank
Chart 14	At island down from DFO camp	N64° 40.319' W140°53.861'	North bank -> south bank
Chart 15	At island down from DFO camp	N64° 40.319' W140°53.861'	Same as 14, north -> south bank
Chart 16	Just down from 14&15	N64° 40.385' W140° 53.888'	Much better, no sub-channels on the north bank. This was just off a small gravel point
Chart 17	Inside island near 16	N64° 40.537' W140° 54.947'	Channel on opposite side of Chart 16. Narrow, about 40 yards in length, <3' depth
Chart 18	None	N64° 40.836' W140°57.742'	South -> north bank. At end of file we turned around, it doesn't actually get deeper again!
Chart 19	Just down from 18		North bank >south bank. About a mile on the Canadian side.
Chart 20	None	N64° 41.062' W140° 57.477'	Up above rock point. North -> south bank. Good south bank profile
Chart 21	At border	N64° 40.894' W140° 59.996'	South -> north bank. Not very good profile
Chart 22	Few hundred yards down from border	N64° 40.976' W141° 00.612'	Not a very good profile
Chart 23	Just upriver of Eagle	N64° 46.541' W141° 04.638'	South -> north bank. File was stopped late; the bottom goes straight up to the shore.
Chart 24	Shade Creek	N64° 53.222' W141°07.619'	South -> north bank. Pretty flat across the majority of the channel.
Chart 25	Just up of 24		Not a favorable profile
Chart 26	Up of 25	N64° 53.165' W141° 06.892'	South -> north bank. Ended file late but looks like a pretty good profile.
Chart 27	Same as 26	N64° 53.165' W141° 06.892'	Repeated 26 but going north -> south bank. Good profile! Width ~300m
Chart 28	Upstream of 27	N64° 53.126' W141° 06.602'	Profile fairly linear

Table 1, continued.

Transect Name	Description	GPS Location	Comments
Chart 29	Calico Bluff	N64° 54.289' W141° 11.560'	East -> west bank. Not a good profile.
Chart 30	Down from 29		Aborted, lost bottom
Chart 31	Near 30	N64° 54.742' W141° 11.292'	West -> east bank. Good chart but bottom is rounded.
Chart 32	Sand bar downstream from Calico Bluff	N64°55.870' W141° 10.374'	West -> east bank. Width ~350m. Good profile, perhaps best. A bit of an island to the west but would have to have high water to get enough water to have a channel

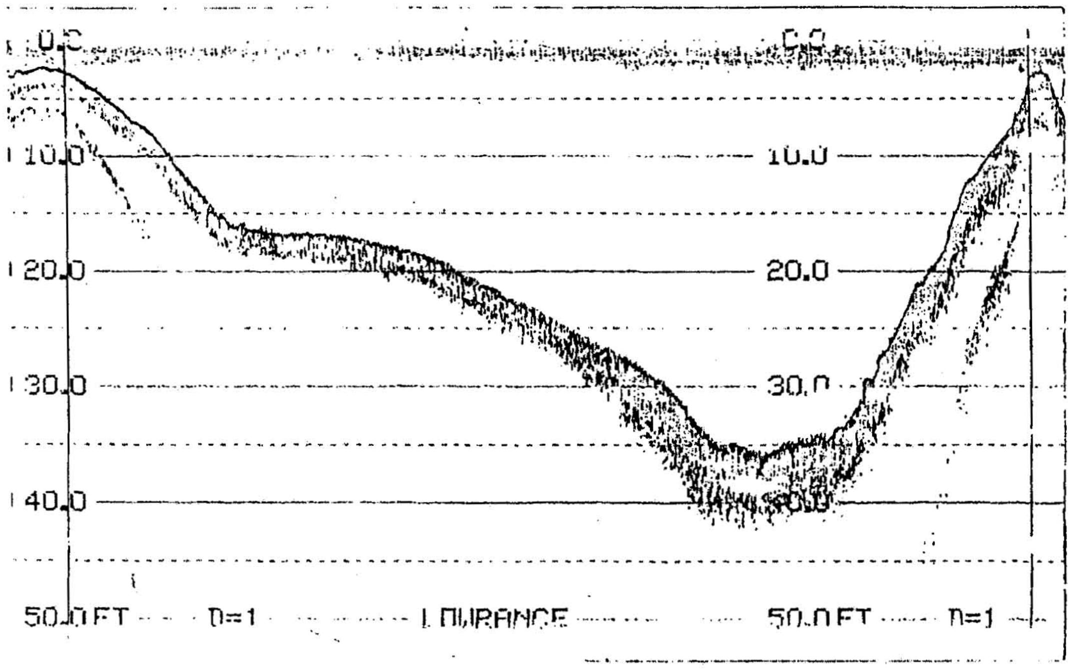


Figure 1. Bottom profile at the Eagle sonar site, 1994. Reproduced from Konte et al. 1996.

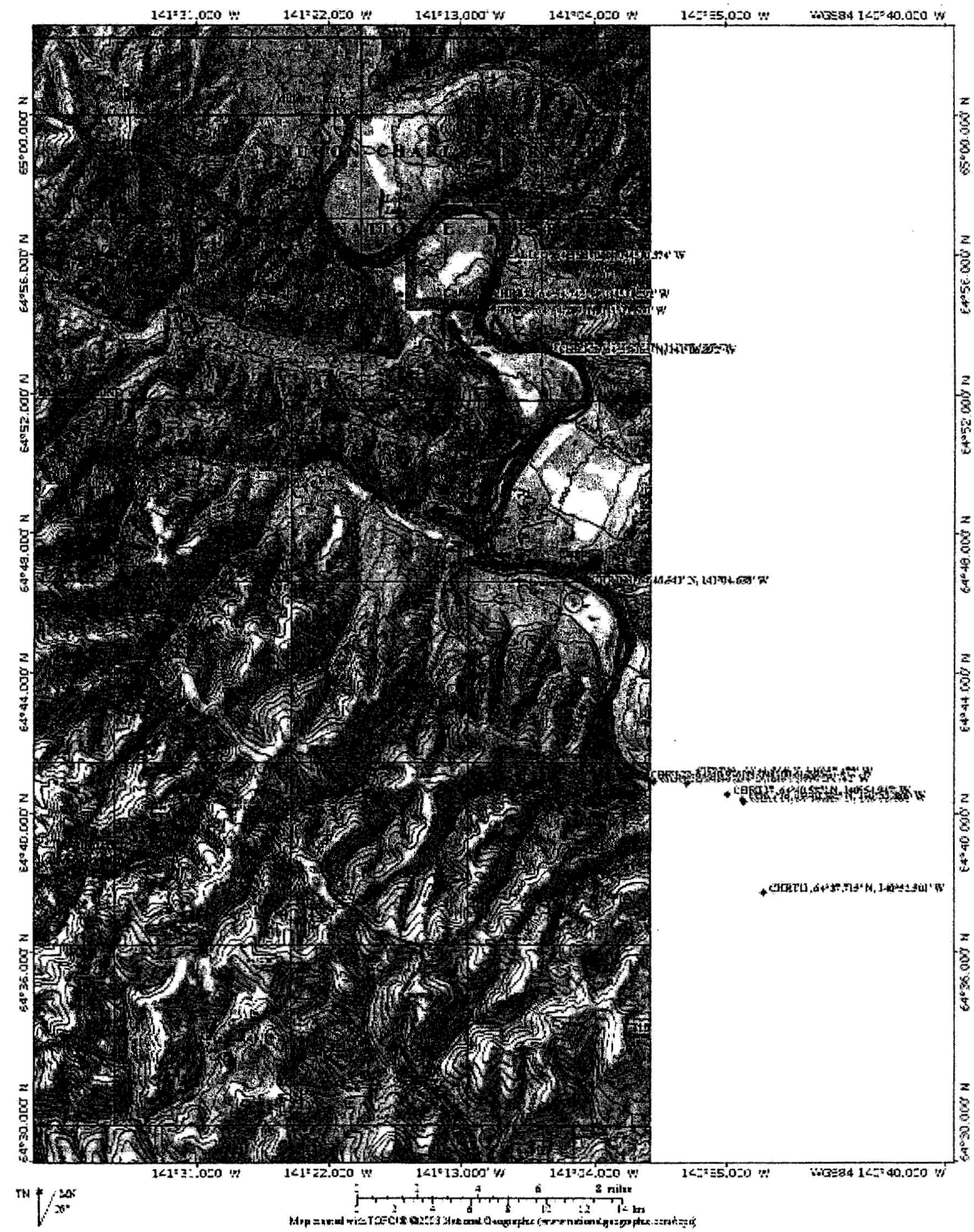
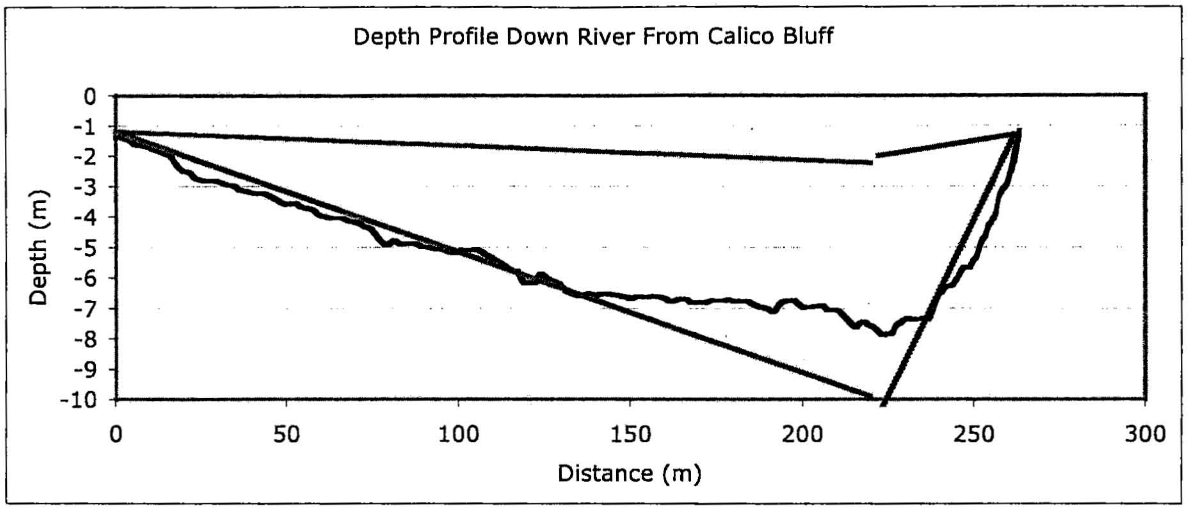


Figure 2. Locations (blue) of transects near the US/Canada border, 2003.



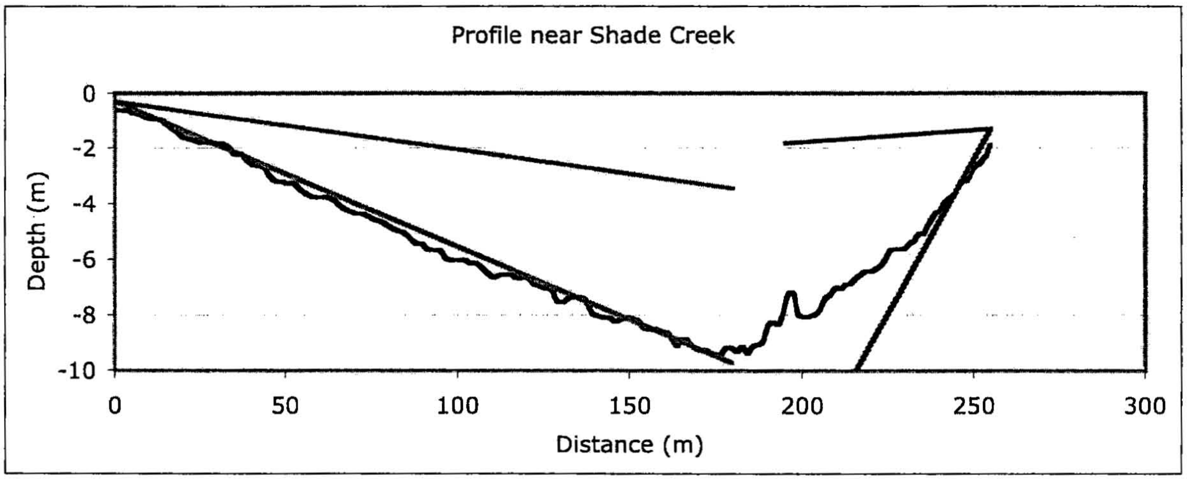


Figure 3. Depth profiles taken near Calico Bluff (top) and Shade Creek (bottom) overlaid with 2° split-beam (green) and 12° DIDSON (red) beams.

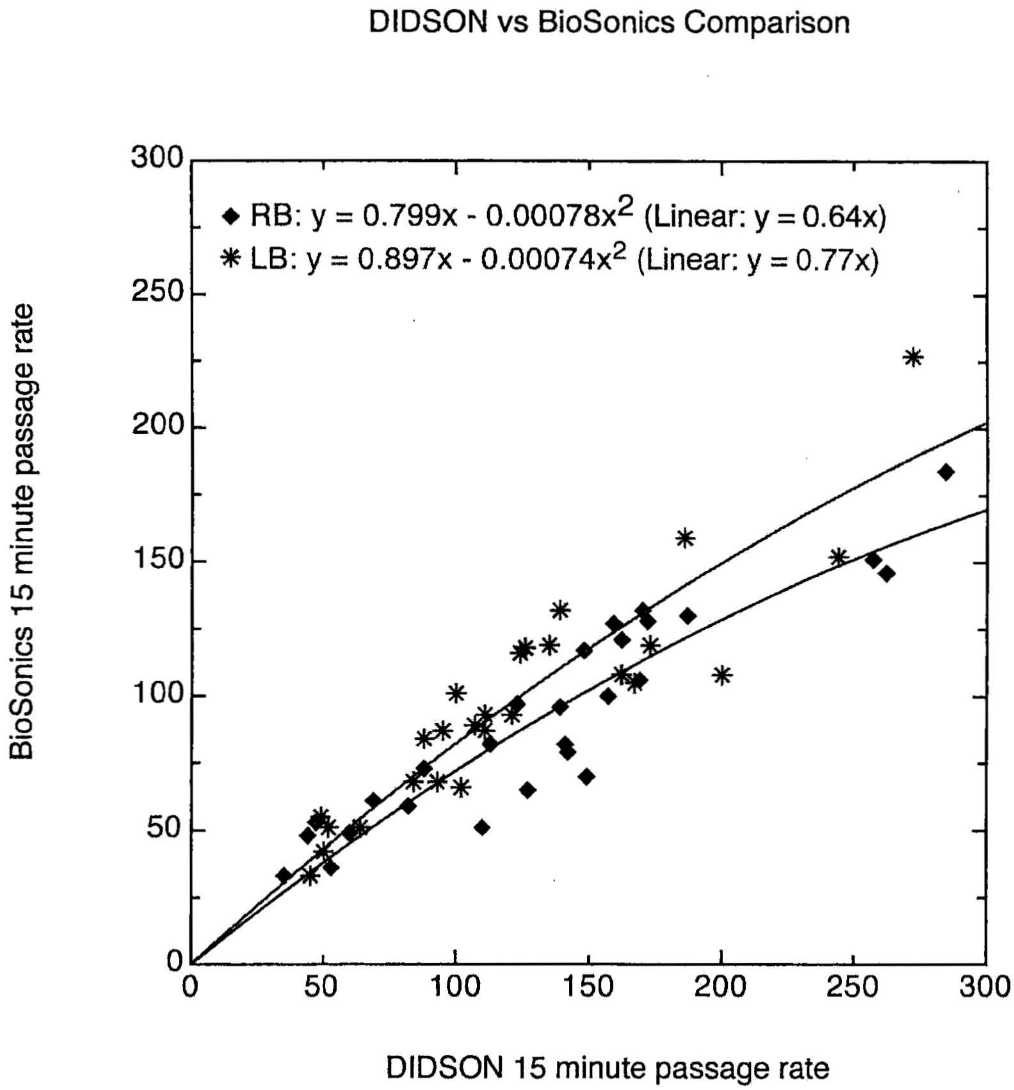


Figure 4. Preliminary right bank (red) and left bank (blue) side-by-side comparisons of 15-minute counts produced by the BioSonics (dual-beam) and DIDSON sonars, Aniak 2003.

Appendix A. Yukon River bottom profiles

Chart 11: White Rock, started out from shore then proceeded in.

Chart 12: White Rock. Shore-to-shore out from the fishwheel. Lost bottom when we got near the island.

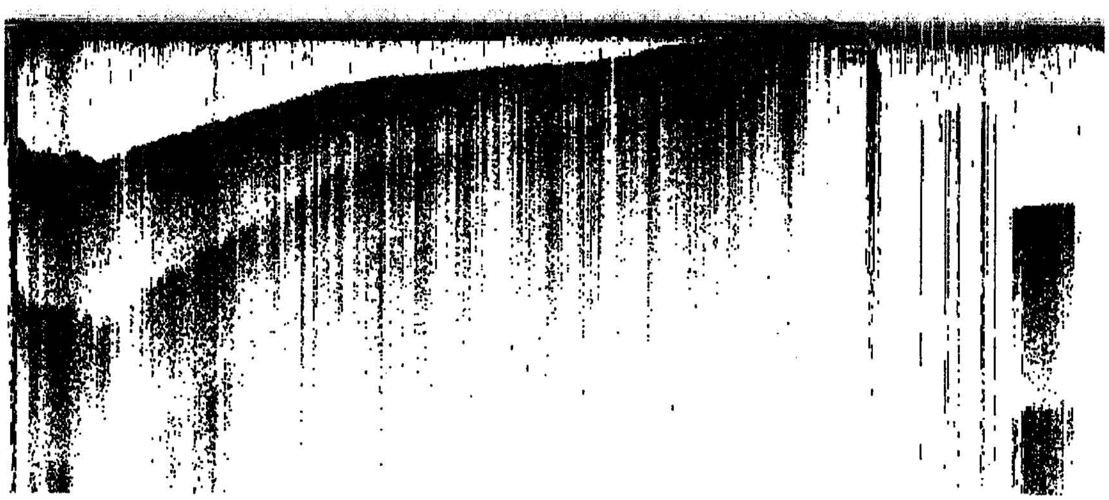


Chart 13: White Rock. Shore to Shore, south bank to north bank

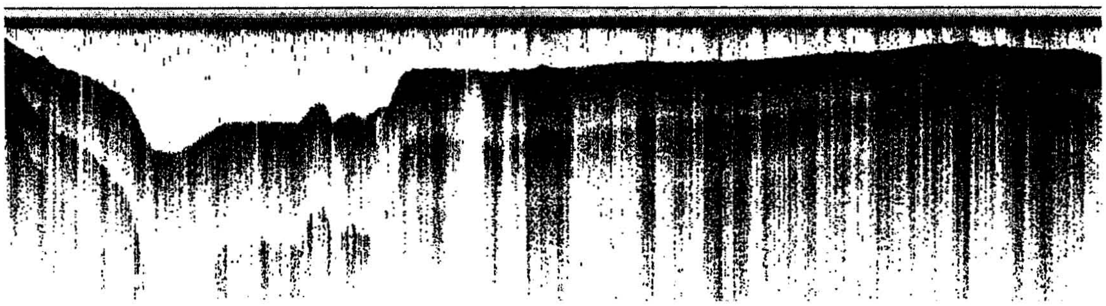


Chart 14: N64°40.319', W148°53.861'. North to south bank at island down from DFO camp

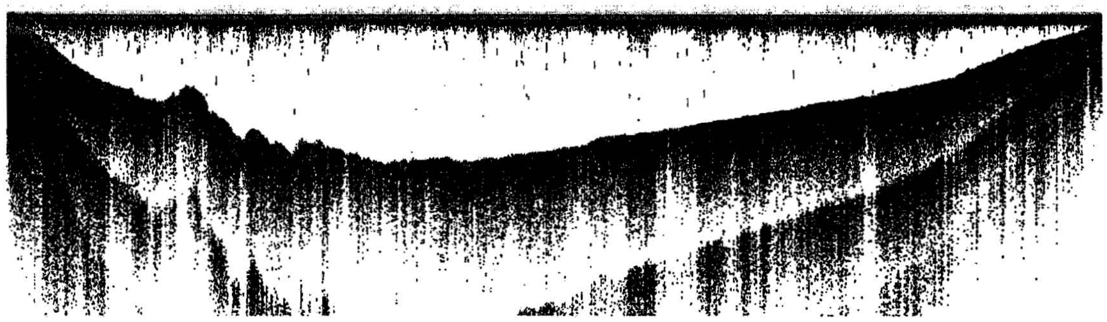


Chart 15: Same as 14 but from south bank to north bank. Lost bottom initially but picked it up at 9' of depth

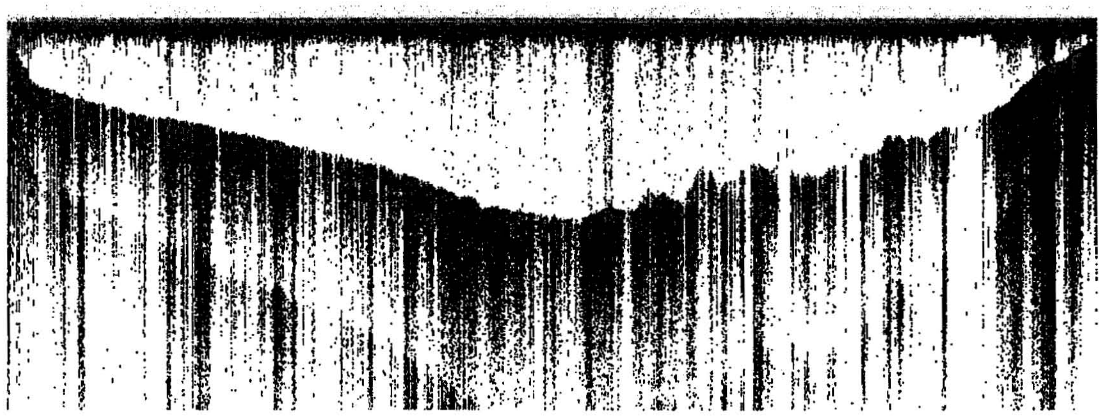


Chart 16: N64°40.385', W140°53.888' just down of 14 and 15. This was off a small gravel point.

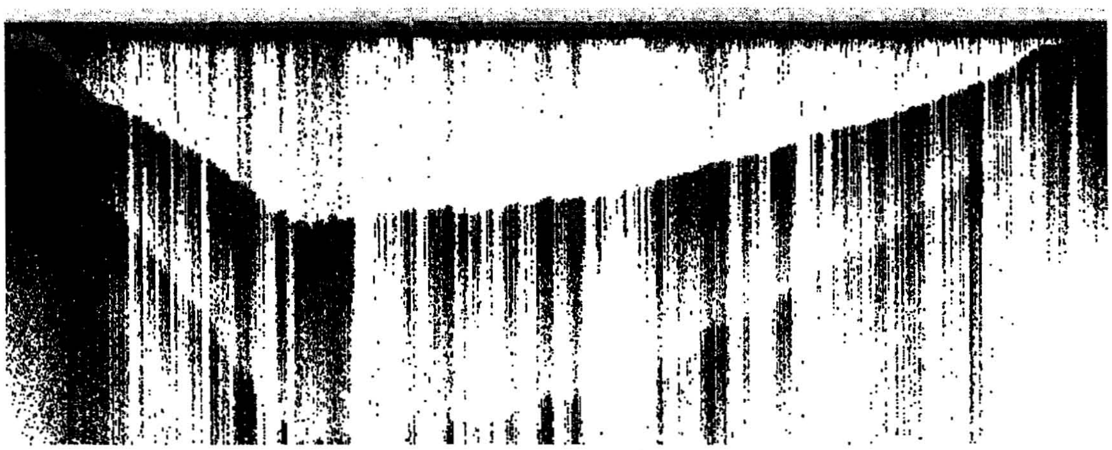


Chart17: The inside channel of island. N64°40.537', W140°54.947'. Narrow little channel (~40 yrds @ 3' of depth))

Chart 18: N64°40.866', W140°57.742'. South bank to north bank. At the end of the file, we turned around, it doesn't go deeper again!

Chart 19: Just down from 18, North to south bank about a mile on the Canadian side.

Chart 20: Up above rock point North to south bank. N 64°41.062', W140°57.477'. Good south bank profile

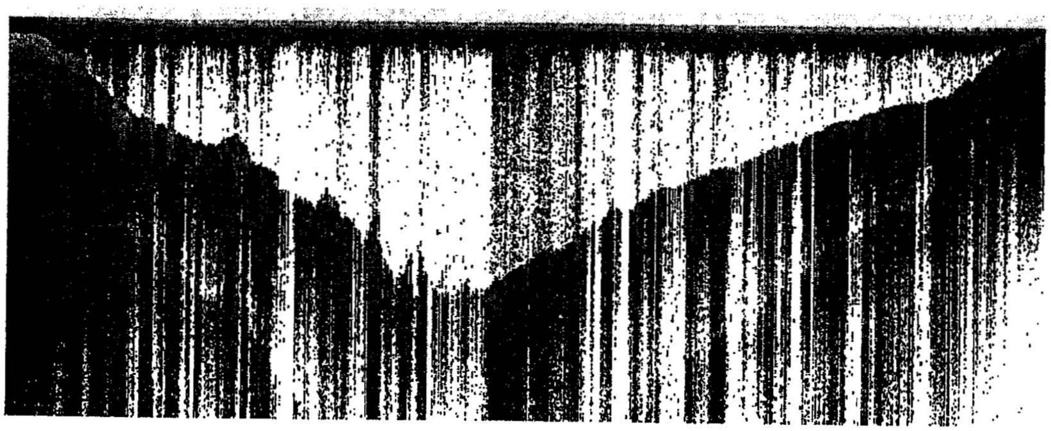


Chart 21: At border, south to north bank. N64°40.894', W140°59.996'. Not very good.

Chart 22: Few hundred yards down from Border. N 64°140.976', W141°00.612'

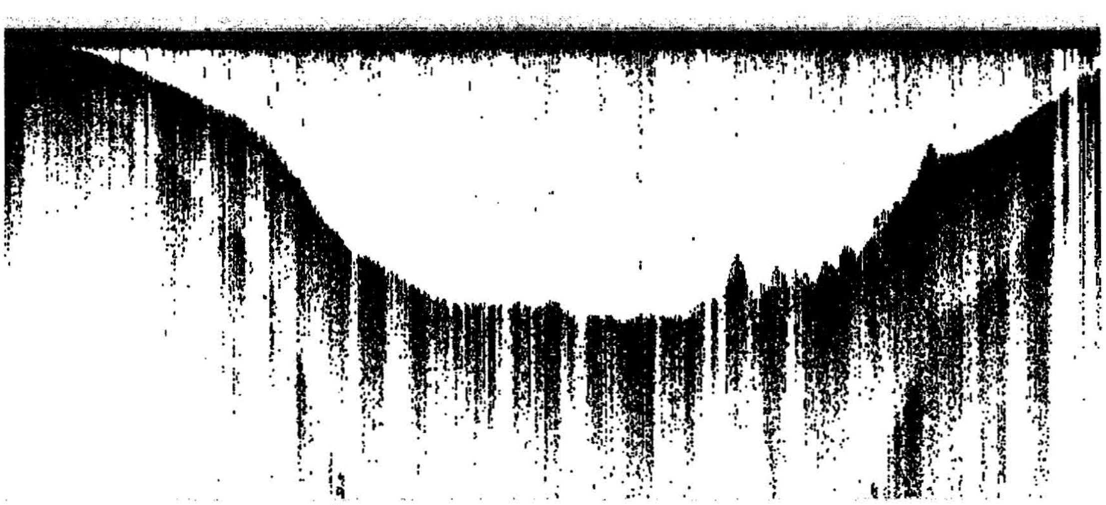


Chart 23: N64°46.541', W141°04.638'. South to north bank, just up of Eagle. The end actually goes straight up to shore. The file was stopped a bit late.

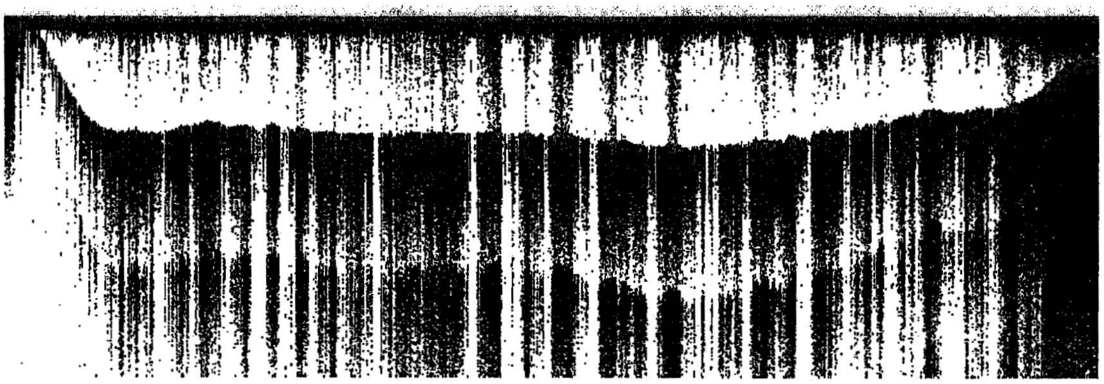


Chart 24: Shade Creek, N64°53.222', W141°07.619'. South to north. Pretty flat on north side.

Chart 25: Just up from 24.

Chart 26: Up from 25. N64°53.165', W141°06.892'. South to north bank. Ended late. Looks like a fairly good profile, at least on the south bank.

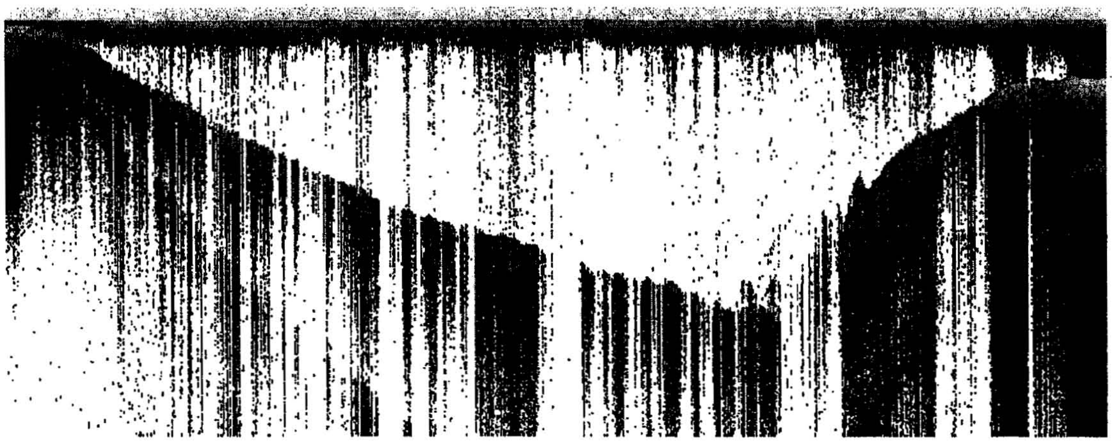


Chart 27 Same as 26 but from North bank to south bank to get a better feel for the North bank. Good chart! Width about 300 yards

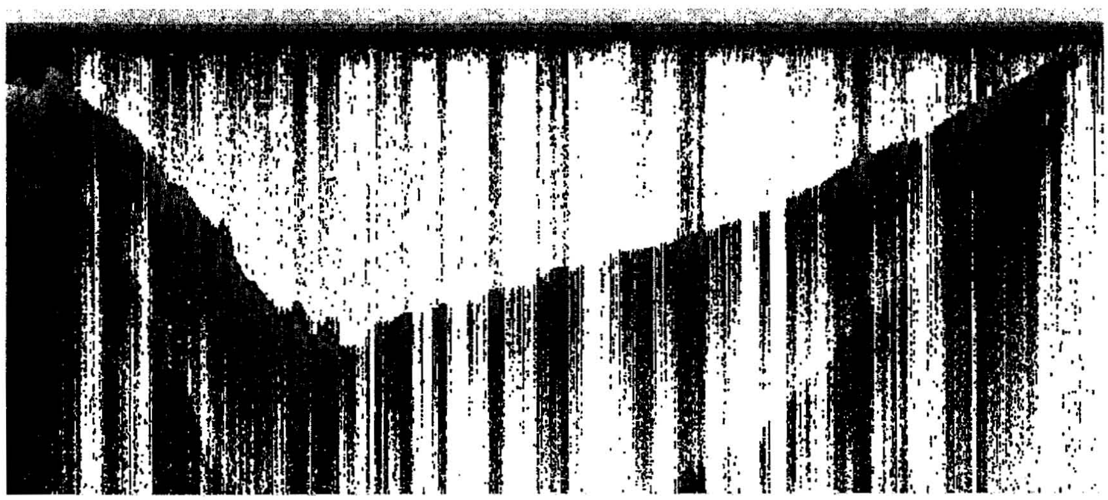


Chart 28: Upstream of 27. N64°53.126', W141°06.602'

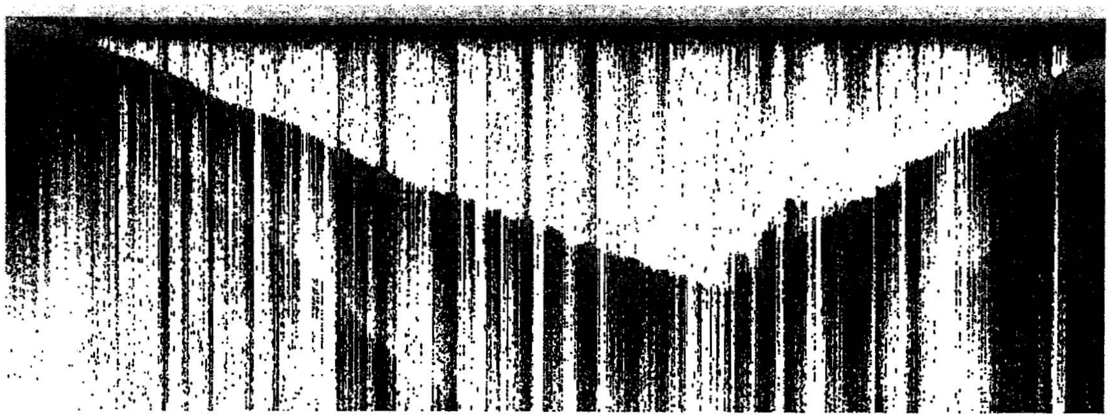


Chart 29: Calico Bluff. N64°54.289', W141°11.560'. East to west bank.

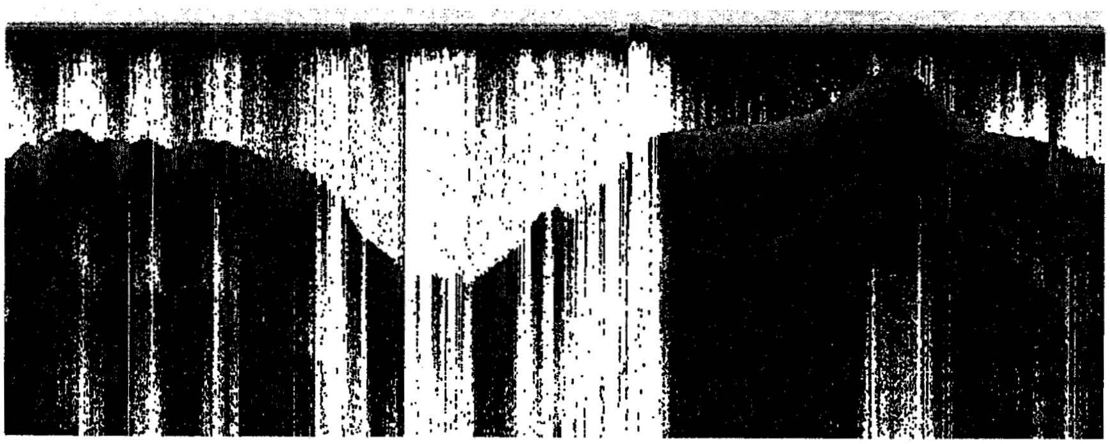


Chart 31: N64°54.742', W141°11.292'. Good chart, went from west to east bank.

Chart 32: N64°55.870', W141°10.374'. West to east bank. Distance about 350m. Good profile, best so far. A bit of an island to the west but would have to have high water to get enough water to have a channel.