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STEELHEAD STUDIES: SITUK RIVER, 1989[1]

By

Robert E. Johnson

Alaska Department of Fish and Game
Division of Sport Fish
Anchorage, Alaska

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ABSTRACT

This study reports summarizes the first year of a two-year study to develop methods for counting and to count the spring run of steelhead *Oncorhynchus mykiss* returning to the Situk River. Recording fathometer (sonar) and visual observations were used to count the early portion of the spring steelhead run returning to the Situk River during 1989. The last portion of the immigrant run and all of the emigrant was counted, and visual and sonar counts were verified, using a weir operated by the Alaska Department of Fish and Game, Division of Commercial Fisheries.

Most upstream movement by steelhead occurred during periods of darkness. There were periods when incorrect sonar settings, incorrect transducer aim, or environmental conditions caused poor correlation of observed versus sonar counts. The correlation between observed and sonar counts improved as methods were refined. The highest correlations between sonar counts and visual observations were achieved when barrier structures were used to constrain steelhead passage into an ensonified channel approximately 35 feet wide. The sonar orientation and control settings that provided the greatest degree of correlation are described.

The total count of immigrant spring steelhead (visual, sonar, and weir) was 2,071. It is likely that a substantial number of immigrant spring steelhead were missed by both sonar and visual counts. The combined number of spring and fall run steelhead that eventually emigrated from the river through the Division of Commercial Fisheries weir, combined with weir mortalities and the sport harvest, totaled 6,234 fish.

KEY WORDS: steelhead, *Oncorhynchus mykiss,* sonar enumeration, transducer aim, barrier structures, escapement, Situk River, Yakutat, southeast Alaska

INTRODUCTION

The Situk River, located on the Gulf of Alaska near Yakutat (Figure 1) contains the largest known steelhead *Oncorhynchus mykiss* population in southeast Alaska. The Situk River is 22 miles long, and has two lakes in its headwaters that have a combined surface area of approximately 992 acres.

Adult steelhead enter the Situk River from the ocean during August-December (fall run) and again during March-June (spring run). Fall run fish generally overwinter in Situk Lake. Most of these fall steelhead re-enter the Situk River to spawn, but an unknown but smaller number enter Mountain Stream, the tributary that connects the two lakes. This spawn timing generally coincides with the return of the spring run of fish to the Situk River from the ocean. Fall run steelhead have been observed to spawn as early as February, but the majority of fall and spring run fish spawn from late April through May and early June. It is not known whether the two runs interbreed. Jones (1983) reported that repeat spawning steelhead occurred at the rate of 24.7 percent, and that some fish returned to spawn as many as four times. Juvenile steelhead reared for two to five years in fresh water, and for one to three years in the ocean before returning to spawn; the dominant age class (32.4%) was 3.2 (Jones 1983).

In 1952, approximately 20,000 to 26,000 post-spawn steelhead (kelts) were counted down through the Situk River weir (Knapp 1952). More recent estimates of the size of the Situk River steelhead population have been substantially lower. Intermittent peak escapement counts from 1960 through 1980 by the Alaska Department of Fish and Game (ADF&G) indicated that the combined fall and spring Situk steelhead minimum escapement was approximately 1,000 to 1,500 fish. Annual counts conducted by the ADF&G during the peak of spawning activity from 1984 through 1989 have set the escapement at 2,048 to 3,206 steelhead. A mark recapture experiment conducted during the spring of 1983 estimated the size of the Situk River steelhead population at approximately 5,000 fish (Jones, 1983).

The Situk River supports a popular spring steelhead fishery and a developing fall steelhead fishery. Angler effort during the peak of the spring fishery has ranged from 6,490 to 11,382 hours from 1985 through 1989 (Table 1). Anglers harvested from 201 to 374 steelhead annually during that period, and released from 1,974 to 4,658 fish. Johnson and Marshall (*In press*) estimated the total 1989 effort for steelhead at 11,078 angler hours and the catch (kept plus released) at 2,416 steelhead. Angler effort and harvest were approximately the same as during the 1988 season, but substantially fewer fish were caught. During the peak of that season, up to 30 boats floated the Situk River in a single day.

Heavy snow accumulations have limited access for sport steelhead fishermen during the winter, and occasionally during the early spring. Accommodations have been a limiting factor during the peak of the spring season. The recent construction of several new facilities, increased winter access via all-terrain vehicle, and increasing numbers of anglers camping will all contribute to the future development of this fishery. Use levels are presently the highest ever recorded, and are expected to increase with moderate annual growth.

To evaluate the impact of this catch and harvest by a growing sport fishery, it is necessary to determine the size of the Situk River steelhead population. This study summarizes the first year of a two-year study to develop methods for counting and to count the spring run of steelhead returning to the Situk River.

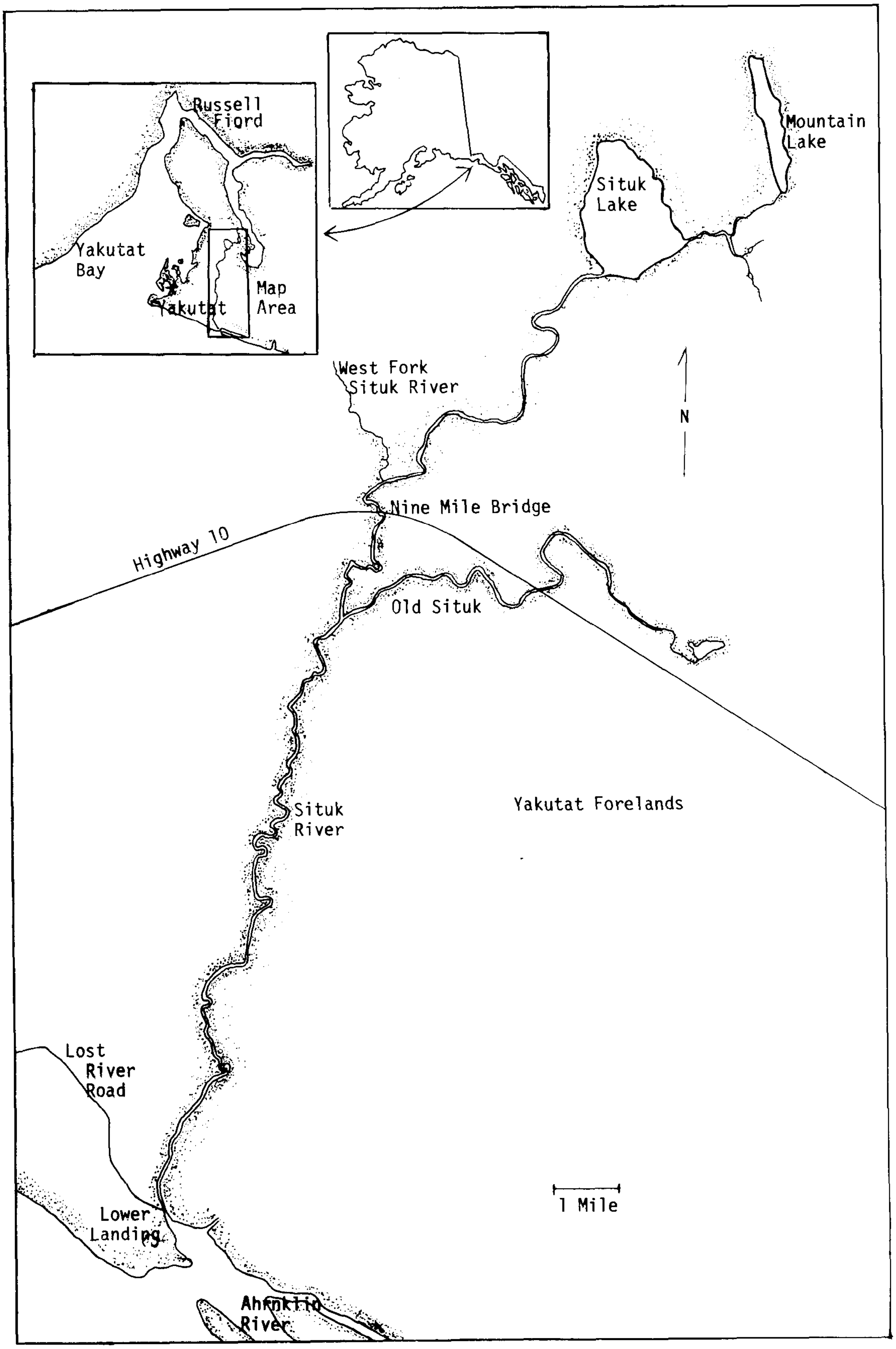

Figure 1. Map of the Situk River system, 1989.

Table 1. Estimated peak angling effort, steelhead harvest and release during the spring Situk River sport fishery, 1985-1989.

Year	Angler Days	Hours Fished	Steelhead Kept	Steelhead Released
1985[a]	1,106	6,490	201	2,485
1986[b]	1,680	9,338	239	2,025
1987[c]	-----	9,136	279	3,603
1988[d]	2,168	11,382	374	4,658
1989[e]	-----	11,078	332	1,974

[a] Mecum and Suchanek 1986 (Survey dates 29 April - 2 June, 1985. The survey missed the early part of the steelhead season).
[b] Mecum and Suchanek 1987 (Survey dates 14 April - 1 June, 1986).
[c] Bingham et al. 1988 (Survey dates 6 April - 31 May, 1987).
[d] Suchanek and Bingham 1989 (Survey dates 4 March - 4 June, 1988).
[e] Johnson and Marshall *In press* (Survey dates 4 April - 4 June, 1989).

METHODS

Study Design

A weir would provide an accurate count of the steelhead run, but it could also delay the run, potentially increase steelhead mortality through predation by both terrestrial and aquatic mammals, and disrupt boat traffic during the sport fishery. The ADF&G Division of Commercial Fisheries was scheduled to operate a weir to count sockeye salmon *O. nerka* during June and July. This weir would record the number of post-spawning steelhead that emigrated from the system (kelts), but would be installed too late to record much of the immigrant run. The weir was to be installed after the peak of the steelhead sport fishery, so its impact on boat traffic would be minimal. Visual counts would not disrupt the run or boat traffic, but would require that personnel be stationed at the site and remain attentive for long periods of time. Sonar counters have none of these disadvantages, since they could be programmed for automated operation. Further, the use of recording fathometers commonly found on fishing vessels to count steelhead would be substantially less expensive than constructing sonar units specifically for this purpose. The feasibility of this particular application, however, was untested. I attempted to develop the necessary methods, and to count steelhead visually, by sonar, or by a combination of both methods, until the scheduled installation of the Division of Commercial Fisheries weir.

In order to use a recording fathometer (sonar) to count steelhead on the Situk River, several initial conditions must be met (David Gaudet, ADF&G, Division of Commercial Fisheries, Douglas, Alaska, personal communication). These conditions were:

1. Only one species (steelhead) may be present at the time of counting;
2. The total run must be less than 10,000, so there is a reasonable chance that targets will be separated spatially;
3. Steelhead must not use the prospective counting site as a holding area;
4. The counting site chosen must be narrow and shallow (less than 65 ft. wide and no more than 4 ft. deep);
5. The location must be acoustically quiet.
6. The water must be clear enough to observe steelhead so that counts may be verified;
7. The bottom must be composed of fine substrate;

A counting site was selected 1.5 miles upstream from the Situk River Lower Landing, approximately 13.5 miles by road east of Yakutat, and approximately 2.25 miles upstream from the mouth of the Situk River (Figure 1). The width of the river at the site averaged approximately 65 feet, with low water minimum and high water maximum widths of approximately 50 and 80 feet, respectively. During average flows, the bottom contour gradually sloped to a depth of approximately 4 feet on the eastern shore. Bottom substrate was composed of sand and small gravel. Tides above approximately 9.0 feet caused elevations of water levels at the site; the water level rose approximately 2 inches on a nine foot tide. Maximum tidal heights at the Situk River mouth are just over eleven feet.

The eastern shore of the river consisted of a vertical sand and gravel bank approximately 8 feet high that was vegetated with climax spruce forest. The western shore of the river was a gravel bar, backed by a bank approximately 3 feet high and vegetated with willow and alder. Camp was constructed on the eastern bank, offering a good view of the river and protection from high water conditions. The proximity of the camp to the river was constrained by the length of transducer cable available (150 feet).

Sonar Counts

Two LOWRANCE X-16 recording fathometers were mounted in the tent frame. Each fathometer contained a micro-computer that could be programmed to perform electronic filtration of noise, depth range, paper speed, sensitivity, and pulse length. These functions were retained while the power was turned off, allowing automatic start-up from a preprogrammed machine. The equipment was powered by a 12 volt deep-cycle lead cell battery; a full charge provided power for approximately five days of continuous operation. Targets detected by the sonar were recorded on 50 foot by four inch paper rolls. Paper speed was programmed by the operator, allowing approximately six hours of operation per roll. Sonar recorders were controlled by a sequential timer; a marker in the timer created a one-eighth inch blank space on the graph each half hour. The condition of the battery was also monitored by a meter in the timer.

A LOWRANCE 8 degree (narrow beam) transducer and a LOWRANCE 20 degree (wide beam) transducer were used. Each transducer was equipped with a 150 foot cable; a resistor had been added to each cable near the sonar connection to compensate for the cable length. The beam spread of each transducer was plotted by physically floating targets through the beam and marking the river bottom with stakes, or by calculating the spread based on the nominal beam width of the transducer at a particular transducer depth and projected distance. The approximate beam spread (W) of each transducer at distance (D) was estimated as $W = 2D \tan\left(\frac{\theta}{2}\right)$, where θ was the beam angle of the transducer. The effective distance of ensonification was the greatest distance at which the beam width matched the depth of the stream. Since the sonar in this installation projected the sonar beam horizontally through the water column, the depth designations on the graph recording represented horizontal distance from the transducer.

A triangular transducer aimer, weighing approximately 100 pounds, was constructed from iron channel (Figure 2). The aimer was four feet high, and was approximately four feet long on each side. The transducer was mounted on the end of a horizontal rod that was suspended from a crossbar between two corners of the frame; the cross bar had three possible vertical (depth) positions. At each cross bar position, aim could be adjusted vertically between 50 and 120 degrees with a mechanical hand crank at the third corner. Aim was adjusted horizontally by pivoting the entire aimer, or by sliding the transducer mounting bar along the horizontal cross bar.

Adjustable controls on the LOWRANCE X-16 included sensitivity (gain), grayline, discrimination, paper speed, range, lower limit, upper limit, surface clarity control, suppression, alternate transmit and print, and pulse length. A variety of settings were tested in order to achieve readable recordings and a high degree of correlation between visual observations and sonar recordings. A proper recording showed a dark, defined bottom mark (at the correct depth [i.e.,

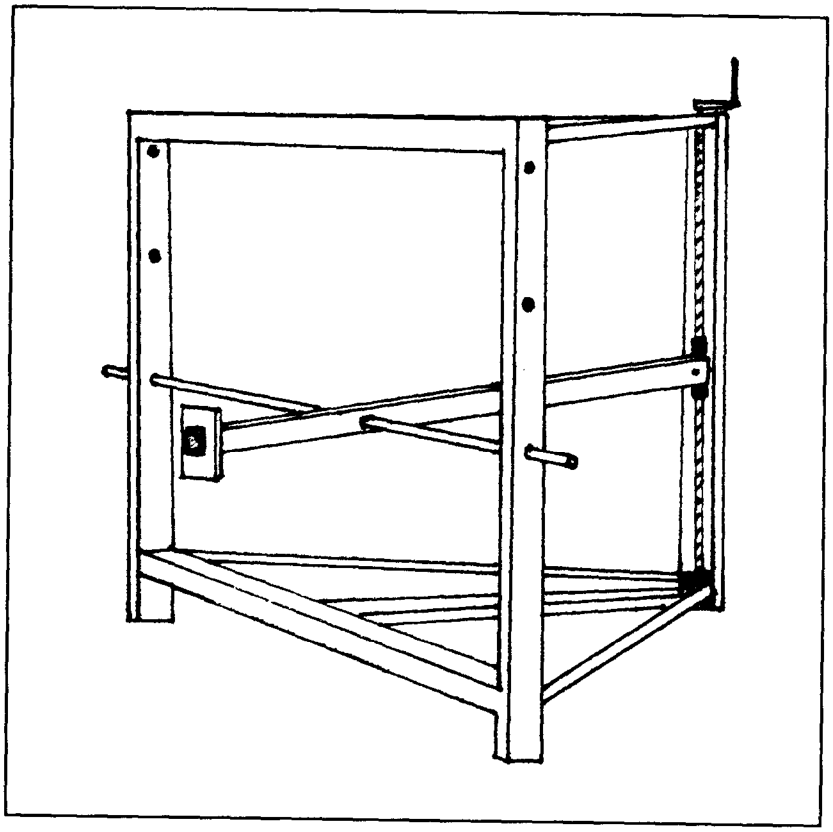

Figure 2. Transducer aiming device used on the Situk River during 1989.

distance] setting), clearly marked debris or targets drifted through the sonar beam, and was free of banding caused by side lobe or improper aim.

Sonar counts were obtained by reviewing the paper sonar chart recording, and counting the number of upstream and downstream targets. Sonar counts were verified through simultaneous visual observation of the sonar chart recorder and of fish travelling past the site by two observers. An observer located in the counting platform informed a second observer in the sonar tent of the number of steelhead passing. If the sonar was adjusted correctly, the targets appeared on the sonar recording after a brief time delay. The delay was a function of the distance the steelhead traveled between the tower and the sonar beam.

During the project, several structures were constructed to enhance and verify sonar counts. To concentrate steelhead along the deeper east side of the river channel and prevent fish from passing below or behind the transducer, a 40-foot barrier was constructed of aluminum channel, iron pipe, and three-quarter inch conduit, supported by wooden tripods (Figures 3 and 4). The barrier extended downstream from the western shore at approximately 110 degrees. A 16-foot iron pipe, channel, and conduit "fence" was constructed along the eastern shore across from the barrier to restrict access by fish to brush and rootwads in that area (Figure 5). The unobstructed passage between the barrier and the fence was approximately 30 feet. Aiming the transducer at the 16-foot fence also restricted the distance that the sonar beam traveled in the water. The "fence" section provided a regular surface to reflect the sonar beam, rather than allowing it to be reflected by the irregular slope of the opposite bank.

It was necessary to position the transducer back from the edge of the 40-foot barrier section because the width of the sonar beam was very narrow close to the transducer, and steelhead passing close to the transducer could easily pass over or under it. The distance that the transducer was set back from the edge of the deep water barrier section was determined by matching the calculated beam spread with the depth of the water at the end of the barrier section.

Visual Counts

A visual counting platform was constructed approximately 120 feet downstream from the tent, and approximately 60 feet downstream from the 40-foot barrier. The platform was constructed from sheets of plywood supported by wooden timber legs, was approximately 16 feet high, and overlooked a shallow area of the river. Immediately downstream from the counting tower, a 32-foot long "fence" of iron pipe, aluminum four inch channels, and three-quarter inch conduit pickets was constructed to divert fish from the bank below the counting platform and facilitate visual counts. An observer in the counting platform could communicate with the sonar tent via hand-held radio.

During periods of darkness, a 300 watt broad-beam halogen floodlight and a 150 watt incandescent floodlight were used to illuminate the shallow water and allow observations. The lights were placed on the 32-foot "fence" below the counting platform, and were powered by a 600 watt gasoline powered generator.

Visual counts were used during periods when the sonar was not operational, and periodically to verify sonar counts. They were conducted by an observer in the counting platform, who recorded the number of steelhead that were observed passing the site in either direction.

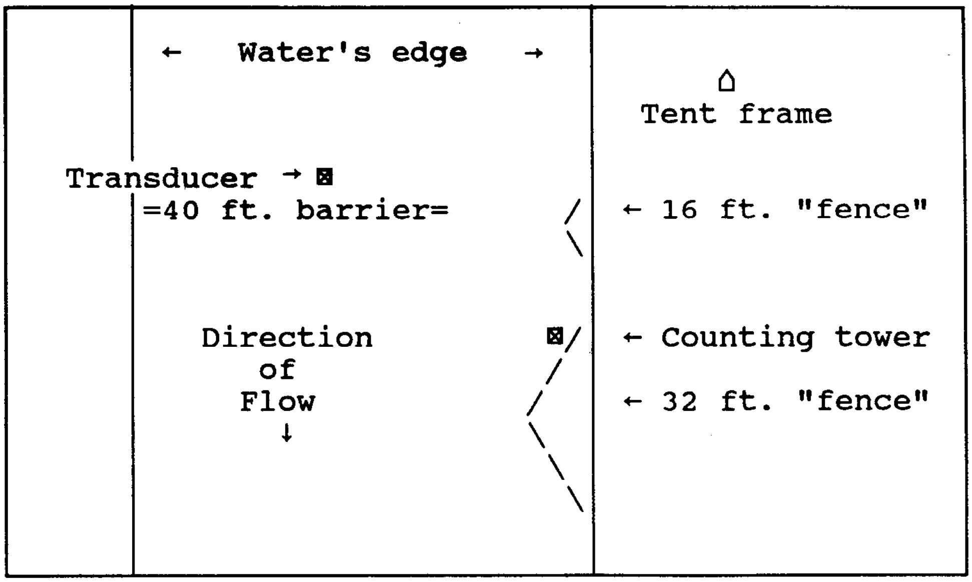

Figure 3. In-water barrier configuration used while counting steelhead with sonar at the Situk River, 1989.

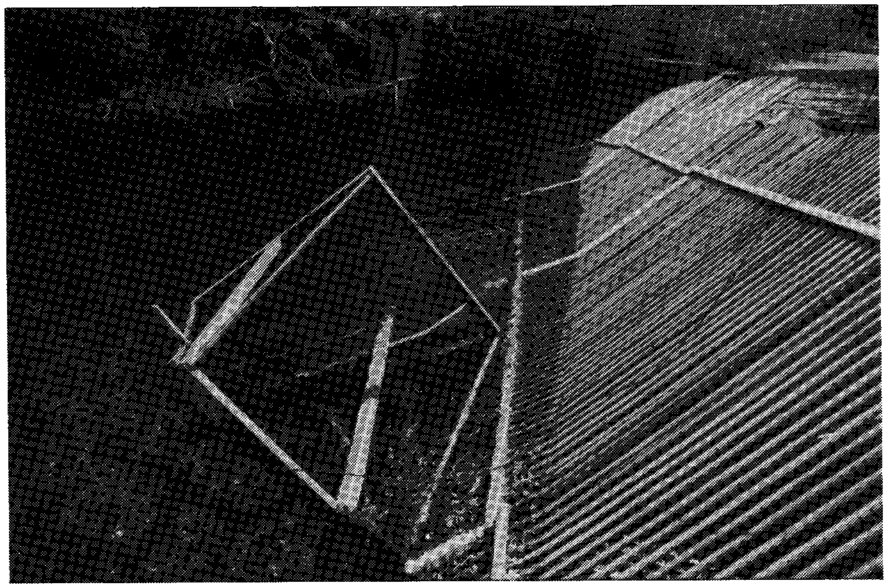

Figure 4. Forty foot barrier and transducer aimer, Situk River, 1989.

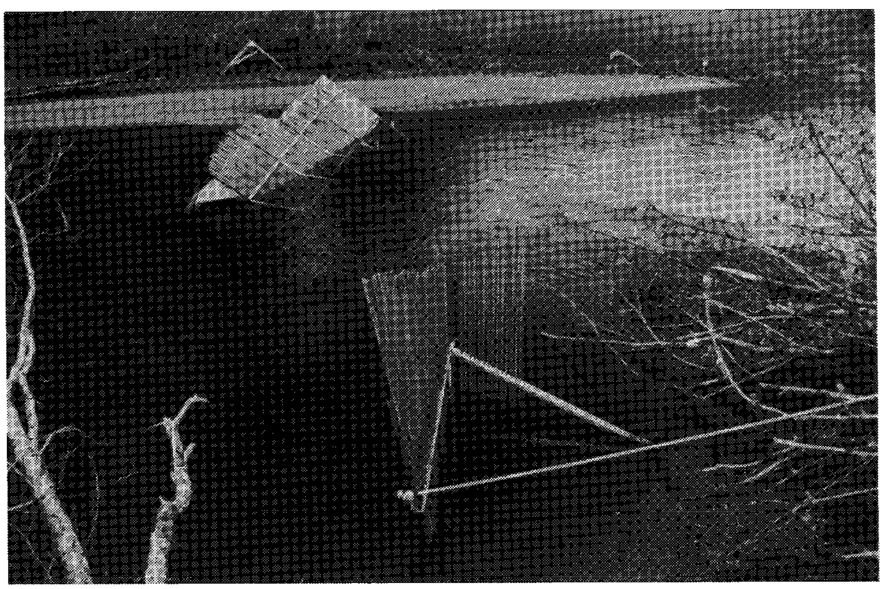

Figure 5. Sixteen foot "fence" (foreground) and 40 foot barrier (background), Situk River, 1989.

RESULTS

Steelhead were first observed in the Situk River on March 27, when 7 steelhead were seen moving upstream on the evening tide. Visual counts were conducted until the sonar was placed into operation on March 31 at 1900 hours, and continued throughout the project. Three steelhead were first observed passing through the sonar beam on April 2, and they created a very faint trace on the sonar recorder. On April 10, three more steelhead were observed travelling directly through the beam, but these were not recorded. On April 12, it became apparent that many steelhead were not being recorded by the sonar, as evidenced by concentrations of steelhead observed above the sonar site each morning with no corresponding sonar record. The transducer without in-water structures was placed near the bottom with and without the aimer, on each shore of the river, in deep water, and in shallow water, but none of these combinations worked well.

The observation platform and in-water structures were constructed, starting approximately April 12, in a attempt to create a design that would allow efficient sonar and visual counts. It was thought that fish travelling close to the eastern bank were not being recorded, so the 32-foot "fence" was constructed to prevent steelhead passage in this area. The transducer and aimer were then placed near the western shore, aimed towards the "fence". The 32-foot "fence" made it easier to observe steelhead from the platform, but had little effect on the efficiency of sonar recordings.

From April 12 through April 18 the sonar was operated only during those daylight periods when steelhead had been visually observed passing the sonar site and throughout the night. Simultaneous observations of the sonar graph and of the river while fish were in the sonar beam were conducted whenever possible, to enable interpretation of graph recordings when visual observations were not possible. Steelhead continued to evade detection by the sonar.

Before April 18, too few steelhead were observed while the site was manned to evaluate sonar adjustments. After lights were installed on April 18, steelhead were observed to travel in greater numbers at night. There were then enough steelhead available to observe the effects that different sonar settings, transducer positions, and aiming had on sonar recordings. From April 18 to April 26, daily visual and sonar counts were maintained during the daylight high tide cycle, and from approximately 2130 hours until 0030 hours under the lights. The sonar continued to record until approximately 0800 hours. Visual counts were performed without sonar on April 27 and 28 due to a recorder paper shortage.

The 40-foot barrier was constructed on April 28. Aimer placement was tested upstream and downstream of the barrier, on the eastern shore aimed toward the barrier, and on the upstream face of the barrier. The 16-foot "fence" was constructed on April 29, and the aimer remained on the upstream face of the barrier aimed toward that "fence" (Figures 4 and 5). That evening, 41 of 44 visually observed steelhead were also recorded on the sonar graph. There were also eight targets recorded by the sonar that were not observed visually. From April 30 until May 29 the same configuration was used. When the equipment was aligned and set properly, all of the observed steelhead were also recorded by the sonar. Sonar settings and transducer aim became misaligned several times during this period, and visual counts were maintained until counting precision was restored. Heavy rain and snow-melt increased water depth by nearly two feet for several days during late May and caused the transducer aimer to be swept into deep water and out of operation. This caused an interruption of both sonar and visual counting for two days until the water level subsided. The ADF&G Division of Commercial Fisheries weir was installed on May 28. Since the weir provided positive counts of immigrant and emigrant fish, both visual and sonar counting were discontinued on that date.

Behavior of Steelhead

Steelhead generally entered the lower part of the Situk River (near the U.S. Forest Service weir cabin) in schools near the peak of high tides. Then steelhead usually separated into smaller schools (6 or less) as they began travelling up the next approximate mile of the river, generally during periods of darkness. Larger schools of steelhead were again observed as they migrated above tidal influence.

From March 27 through April 7, steelhead were observed to travel during daylight hours within one hour before and after the high tide. From April 8 through May 1, the numbers of steelhead traveling past the site began to increase approximately 1.5 hours before high tide, and began to decline by the peak of the tide. Lights installed on April 14 enabled observation of steelhead at night. After April 15, the greatest numbers of steelhead were observed to pass the site between 2000 and 2400 hours, regardless of the tidal stage; there was a lesser, but predictable period of movement near daily high tides. Darkness seemed to be the primary factor influencing steelhead movement in the Situk River. Steelhead arrived at the sonar site correspondingly later in the evening during the lengthened days of spring.

Undisturbed steelhead provided the strongest sonar targets. Steelhead travelling in a undisturbed state generally travelled off the bottom, in a straighter path, and at a slower speed, which caused them to remain in the beam in a better location for a longer period. While undisturbed steelhead provided the most reliable sonar recording opportunities, they were also the most difficult to confirm visually during periods of darkness. The addition of lighting allowed visual counts and observations at night, but it also modified fish behavior. Modified behavior varied from rapid and unpredictable movement within the river when extremely intense (200,000 candlepower) light beams were encountered, to holding behavior (sometimes for several hours) beneath the 150-300 watt wide-beam floodlights. Both reactions sometimes made it difficult to obtain accurate counts of steelhead, but the floodlights were used for most of the project.

Identical lighting conditions produced a wide range of responses from individual steelhead. Some steelhead were apparently indifferent to the lights, while others swam rapidly from one side of the river to the other, up into the unlit area and then back down into the light, or down through the lighted area. Effects on steelhead behavior were evident on the sonar graph during periods of darkness when the lights were not in operation. Steelhead tended to travel mid-stream, mid-water column, and in small, evenly spaced groups through the ensonified corridor when the lights were turned off, as evidenced by the position of targets on the sonar graph. Steelhead targets were more erratic, and less distinct when the lights were in operation. It was important that the lights remain stationary regardless of intensity to minimize negative responses in the passing steelhead.

Transducer Selection and Aim

Fish targets were not recorded consistently with any combination of transducer position and aim with the 20 degree transducer. The 8 degree transducer throughout most of the study.

When the sonar beam was projected into a water column narrower than the width of the beam, the energy grazing the surface and bottom of the river was reflected back to the transducer as interference, blocking portions of the graph recording with dark bands (Figure 6). This interference disrupted the recording if the gain was set high enough to record steelhead at distances over 40 feet in this application, regardless of target strength; beyond that range beam spread exceeded the four to six foot average depth of the water column. Interference also occurred if the sonar beam was aimed too high or low in the water column. If it struck either the surface or the bottom before reaching its intended range, interfering returns were received at distances less than intended. Side-lobe interference, the signal returned by energy encircling the main sonar beam, caused similar banding patterns on the graph if the transducer was placed in the water column closer than 15 inches to either the surface or the bottom.

Interference was minimized when the 8 degree transducer was in water approximately 30 to 40 inches deep, halfway between the bottom and the surface, and aimed one or two degrees toward the surface. At this depth (during normal stream flows) the transducer was located on the face of the barrier sections approximately 16 feet from the deep end.

The transducer was also aimed approximately 105 degrees downstream. With this beam angle, steelhead coming up the river generally created a broad line on the recording that was angled up and to the right (/) (Figure 7). There were also instances when steelhead travelling in an upstream direction made recorded marks that were roughly "s," "v", or "w" shaped. Downstream travel direction was usually recorded as a broad slash to the left (\). It was not possible to confirm whether downstream steelhead targets on the sonar were truly emigrant fish, or if they were immigrant fish that were temporarily headed downstream and would eventually return past the site again. Ice, sticks, and other debris floating or tumbling down the river created fine lines on the graph that were straighter and more vertical than the marks made by fish (Figure 8).

Sonar Control Settings

The following settings produced the greatest correlation between visual steelhead observations and recorded sonar targets:

Upper Level	= 3 ft.	(this reduced surface clutter without the need for electronic filtration)
Lower Level	= 38 ft.	(greater distances caused interference in this shallow water application)
Discrimination	= 0	
Suppression	= 1	
Pulse	= 30 μsec.	
Paper Speed	= 3	(will run approximately 6+ hours)
Gray line	= 4	(approx.)
Gain	= 7	(approx.)

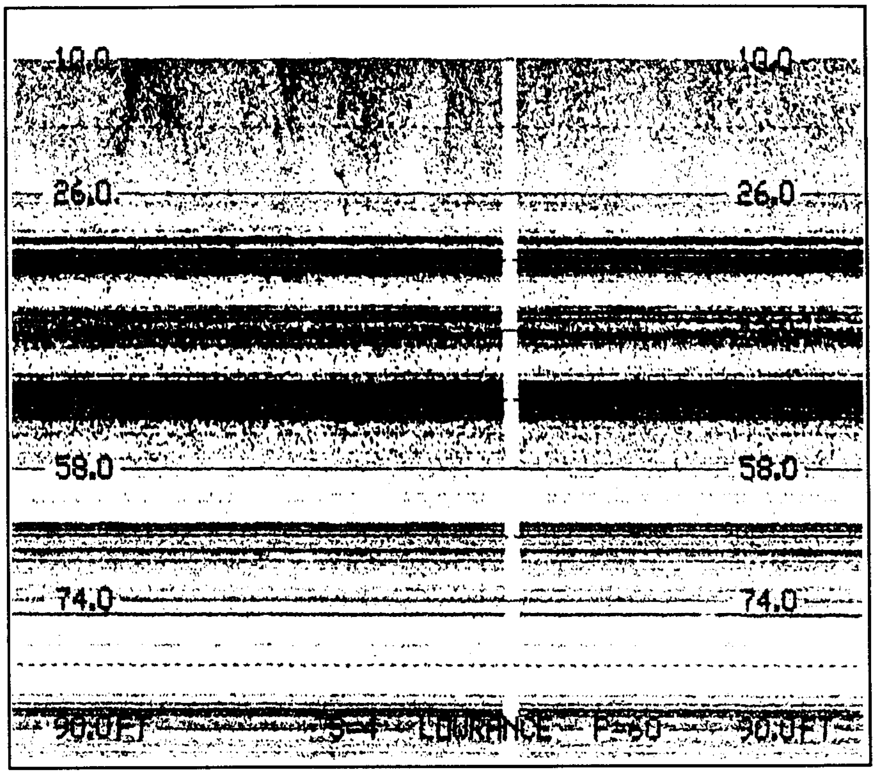

Figure 6. Sonar recording showing interference bands and an extended bottom limit at 90 feet.

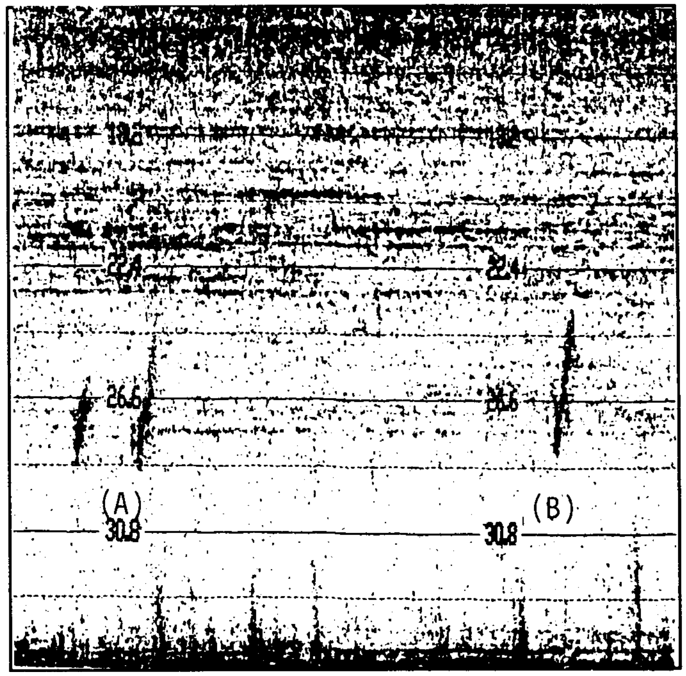

Figure 7. Sonar recording with maximum allowable gain showing recordings made by two steelhead (at A) and by a single steelhead (at B) traveling in an upstream direction.

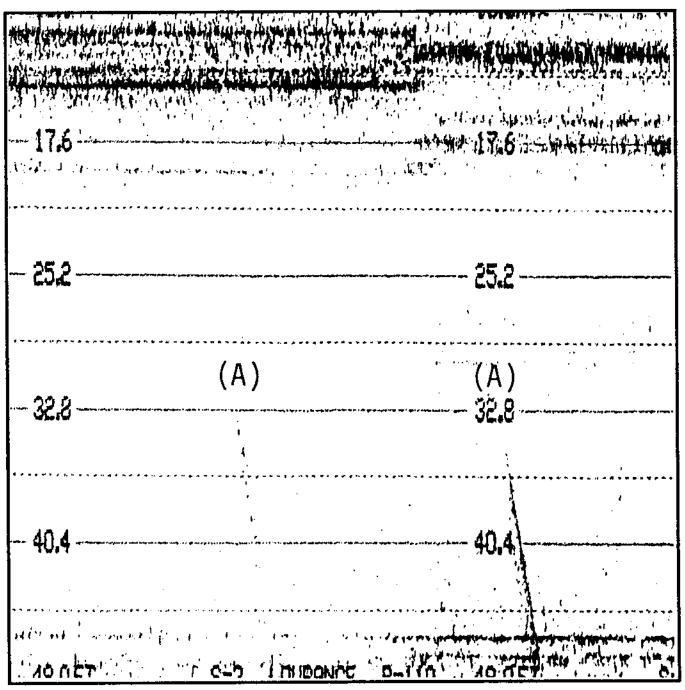

Figure 8. Sonar recording showing two recordings made by debris (at A) traveling in a downstream direction.

Steelhead Population Size

A summary of sonar and visual steelhead counts is presented in Table 2. Precision improved, measured by simultaneous visual and sonar count comparisons, as sonar adjustments and barrier configurations were refined. During 31.5 hours simultaneous observations during peak periods of fish movement from April 18 through April 26, only 17 steelhead were recorded by the sonar while 26 steelhead were observed visually (65% agreement). From April 29 through May 26, however, 120 steelhead were recorded by the sonar and 123 steelhead were observed visually (98% agreement) during 10.5 hours of simultaneous observation. On four evenings of simultaneous visual and sonar counting during this period, visual counts recorded greater numbers of fish on two evenings, and there were two evenings when both methods recorded the same numbers of fish.

It was not possible to determine which steelhead were passing downstream through the sonar beam as kelts that would not return, and which were just temporarily passing back down only to return later. This was not a problem during the early part of the season before any reported spawning; all downstream targets during that period were assumed to be steelhead that were not committed to upstream migration, or were fish that had been spooked temporarily down through the beam. Experimentation with lighting increased the frequency of these downstream fish early in the season, but their numbers lessened when the final lighting configuration was established. These fish were subtracted from the total count until a definite pattern of downstream migration was observed beginning the second week of May.

The size of the 1989 immigrant steelhead population was estimated by adding the numbers of steelhead observed during sonar-only operations (896 fish), the numbers of steelhead observed during visual-only operations (678 fish), and by greater of the numbers of steelhead counted by either method during periods of simultaneous counting (363 fish). There were also 134 steelhead counted upstream through the Situk River Weir from May 28 through August 17,1989 (Keith Weiland, ADF&G, Division of Commercial Fisheries, Yakutat, Alaska, personal communication). Thus the minimum size of the total spring immigrant Situk River steelhead population in 1989 was estimated to be at least 2,071 fish.

DISCUSSION

Sonar Control Settings

Sonar controls were best set after a rough transducer position and aim were established. The gain control, which regulated the amount of energy emitted by the transducer, required the most careful adjustment of the settings, especially when the sonar was first switched on. Aiming the transducer without any electronic noise filtration (i.e., surface clarity, suppression, or discrimination) turned on allowed precise aim of the strongest energy beam through the water column. Setting "SCC" (surface clarity control) and "D" (discrimination) at their lowest levels produced the most reliable targets. If it appeared necessary to set either of these settings higher than 2 or 3 on a scale from 0 to 7 (SCC) or 0 to 4 (D), the aim or the position of the transducer was incorrect and would not record passing steelhead.

Rain, turbulence, water level, tidal influence, and the temperature of the water affected sonar sensitivity. Use of the various programmable electronic noise filters helped minimize these effects, but filtration could easily be increased

Table 2. Numbers of immigrant steelhead counted by sonar and by visual observation, and numbers of hours counted, in the Situk River, 1989.

Dates	Type of Count[a]	Sonar		Visual		Hours of No Counts[b]
		Hours	Steelhead	Hours	Steelhead	
3/27 - 3/31	S/V	0	-	23	7	97
	SV	0	-	0	-	-
4/1 - 4/11	S/V	179.5	0	0	-	4.5
	SV	80	4	80	146[c]	-
4/12 - 4/17	S/V	63	27	27.5	0	22
	SV	31.5	1	31.5	26	-
4/18 - 4/28	S/V	48	325	66	613	116.5
	SV	33.5	17	33.5	68	-
4/29 - 5/26[d]	S/V	276.5	544	65.5	58	319.5
	SV	10.5	120	10.5	123	-

[a] S/V = Sonar counts only, visual counts only, or no counts of either type. SV = Simultaneous visual and sonar counts.

[b] After 4/12, hours of no counts generally occurred during periods when little movement of steelhead had been observed.

[c] This includes 132 steelhead that were visually counted in the area approximately one mile above the sonar site.

[d] Flood for two days (5/15 and 5/16); no sonar or visual counts during this period.

to the point where steelhead targets would be eliminated. The surface clarity control filtered scatter approximately one-half to one-third of the way to the bottom limit of the graph. The discrimination filter worked best on scatter from the bottom limit to approximately one-third of the distance to the upper limit of the graph. Heavy rain, wind, or combinations of both caused periods when the graph was completely darkened, and no combinations of machine settings, transducer aim, or placement were found that allowed targets to be recorded. Turbulence and bubbles from motorboats travelling upstream caused the graph recording to be disrupted, sometimes for up to five minutes. Downstream boat traffic generally caused only minor disruptions.

Sonar pulse length affects the ability of sonar to separate targets. The Lowrance sonar unit allowed the setting of pulse lengths from 30μs to 1700μs. A setting of 30μs allowed a theoretical separation of targets one inch in length, and was used in this application because it projected less energy into the water and reduced interference.

Paper speed also affected the ability to record and separate steelhead targets. Faster paper speeds generally allowed the greatest separation of targets, but a balance was necessary to allow efficient use of paper. A setting that allowed a roll of paper to last for six hours (approximately 1.5 inches per minute) provided adequate separation of targets.

The graph paper obtained from Lowrance Electronics, Inc. was firmly attached to the core of the roll. If the sonar was allowed to run to the end of the paper roll before it was shut down, the machine required repairs because the gears were eventually damaged. It was necessary to unroll and lightly tape the graph paper to the core if there was a chance that the operator would not be present when the roll ended.

Steelhead Population Size

I have little confidence that the estimate of 2,071 spring steelhead returning to the Situk River during 1989 is accurate. I do not know how many steelhead passed the site undetected while adjustments were being made to the sonar configuration, especially during the period before the lights were installed. From March 27 through April 11, only 4 steelhead targets were recorded by the sonar, while 14 steelhead were visually observed passing the site during daylight hours. During the same period, however, an additional 132 bright steelhead were observed concentrated in the area one mile above the sonar site.

The numbers of fish eventually counted out of the river also do not appear support the immigrant sonar count. By August 17, 5,755 steelhead had passed downstream through the Division of Commercial Fisheries weir (Keith Weiland, ADF&G, Division of Commercial Fisheries, Yakutat, Alaska, personal communication). Based on angler surveys, the 1989 spring sport steelhead harvest was 361 fish (Johnson and Marshall, *In press*). Adding the weir steelhead mortalities (118), downstream weir steelhead counts, and the total sport harvest produces a minimum estimate of the total (spring 1989 plus fall 1988) steelhead run to the Situk River of 6,234 fish. The overwintering fall component of the Situk River steelhead has been assumed to be smaller than the spring component, and this could indicate that fall component was much larger than expected. It is more likely, however, that a substantial number of steelhead were missed by the sonar.

Effectiveness of Sonar

During those periods when the sonar did not record passing steelhead, the cause was generally improper placement or aim of the transducer, or undesirable steelhead behavior caused by project-related stress. There were also less frequent periods when environmental factors interfered with graph recordings.

Initially, steelhead were not counted because I assumed that steelhead would be recorded if the sonar was accurately recording sticks, rocks, or partially filled bottles passing through the sonar beam. Inanimate objects can be used to define the sonar beam for aiming purposes, but the sonar may record these objects strongly and still fail to record fish.

The strength of a sonar target varies according to the angle and distance at which it is intercepted by the sonar beam (Gaudet 1984). Accordingly, the strongest sonar beam reflectance came from the side of steelhead perpendicular to the axis of the sonar beam. While targets were very strong when the beam angle approached 90 degrees to the river channel, it was impossible to determine the direction that these fish were traveling. To determine direction it was important that the downstream angle of the beam be maintained at 105 degrees (± approximately 2 degrees). At angles greater than approximately 105 degrees, the beam intercepted steelhead at such a narrow angle that the recording was weak or non-existent. At any angle approaching 180 degrees, steelhead were virtually invisible to the sonar due to the streamlined surface presented to the sonar beam.

Correlation of visual and sonar counts reached 100% on several occasions. With the proper site and sonar configuration, accurate counts of undisturbed fish travelling off the bottom, in mid-channel, and at a moderate speed were possible.

Recommendations for Future Work

The current transducer aimer design did not allow enough adjustment to permit operation in or during low water levels. The front elevation cross bar should be modified to allow stepless lower adjustments via a hand crank similar to that used to adjust the rear of the transducer arm.

I still do not know how to manage the high water situations caused by 9.5+ tides or by rainfall. During these situations, the match between the beam spread and the water column deteriorates. I intend to explore the use of a second portable transducer aimer to ensonify those portions of the water column not covered by the primary unit. The wide angle transducer should, in theory, work better in deep water situations, and may be more effective for this application.

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