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Togiak River Salmon Weir
Phase I – Weir Feasibility Study,
Togiak National Wildlife Refuge, Alaska

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TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA

US Fish and Wildlife Service
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TOGIAK RIVER SALMON WEIR PHASE I-- WEIR FEASIBILITY STUDY, TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA

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Abstract.! A site evaluation on the lower Togiak River was conducted on May 5 and 6, 2000 to determine the feasibility of installing a resistance board weir to estimate salmon escapement. After reviewing the available flow data and conducting an on-the-ground site assessment, we feel that operating a weir on lower Togiak River to assess salmon abundance is not practical. Installing a weir at low flow appears feasible, but it would be difficult to maintain and operate through the salmon migration. Instead of operating a weir on the mainstem Togiak River, we recommend using a combination of escapement counts on 2 or 3 tributaries and an estimate of the proportion of these fish harvested in the commercial and subsistence fisheries to estimate total run size.

Introduction

Subsistence is a way of life for most residents of the communities within and adjacent to the Togiak National Wildlife Refuge. Wolfe et al. (1984) characterize a mixed subsistence-market economy where subsistence resources play a prominent role in the economy and social welfare. Subsistence fishing and hunting provides a "reliable economic base" and a family's subsistence production is "augmented and supported by cash employment of family members." Salmon has always been the mainstay of the subsistence in southwest Alaska.

The Togiak River, on Togiak National Wildlife Refuge, has runs of chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*) salmon (U.S. Fish and Wildlife Service 1986). These fish support subsistence, commercial, and sport fisheries that are important to the culture and economy of the local area. The Alaska Department of Fish and Game (ADF&G) manages the escapement for the Togiak River at 10,000 chinook, 50,000 coho, and 150,000 sockeye salmon annually (Alaska Department of Fish and Game 1990). No specific Togiak River escapement goal for chum salmon has been set, although the goal for the Togiak District, which includes fish returning to several river systems, is 200,000. No escapement goal is set for pink salmon because they are not targeted by the commercial fishery. To conserve

the resource and provide a sustained yield, accurate and timely escapement estimates are necessary for the management of Togiak River salmon.

The ADF&G uses tower counts, aerial surveys, and commercial catch data to manage Togiak River escapement (Alaska Department of Fish and Game 1990). At present, sockeye salmon escapement estimates are based on tower counts at Togiak Lake, 97 river kilometers from Togiak Bay. Fish are counted at the tower 10 to 14 days after they escaped the commercial fishery in Togiak Bay (Brannian 1982). Because commercial fishing is permitted about four days per week (Monday through Thursday), two fishing periods can occur before migrating fish reach the tower, a considerable lag time for in-season management purposes.

Aerial surveys are used to supplement the tower counts, but they are often curtailed due to weather and turbid water conditions. The result can be unequal coverage within a season and between years. Aerial surveys provide only instantaneous, rather than total escapement estimates.

Because the tower only estimates a portion of the sockeye salmon escapement, the lag time between the commercial fishery and the estimate, and other species are not counted, the ADF&G studied the practicality of using Bendix sonar to estimate salmon escapement into the Togiak River in 1983 and 1984 (R.E. Minard, Alaska Department of Fish and Game, personal communication). The sonar was operated from late July through mid August in 1983 below the Gechiak River. In 1984, the sonar system was operated from late June to late July at several locations along the Togiak River. This research showed that the best sonar site was located about one mile upriver from the Pungokepuk River. Although the 1983 and 1984 sonar studies identified a suitable site to operate the sonar, problems with species apportionment were encountered. Research was not conducted in 1985 and 1986 due to funding constraints.

In 1987, 1988, and 1990, the King Salmon Fishery Resource Office continued the feasibility investigation of using sonar in the Togiak River to estimate salmon escapements (Irving et al. 1995). Two sonar stations were set up opposite each other at river kilometer 30 and were operated 24 hours per day, seven days per week. Catches from gill nets with 12, 14, and 20 cm stretch mesh, a beach seine, and visual observations were used to estimate species composition. Length and sex data were collected from salmon caught in the nets to assess sampling bias.

In 1987, sonar was used to select optimal sites. In 1988 and 1990, the sites identified in 1987 were used to estimate the escapement of five salmon species. Sockeye salmon escapement was estimated at 512,581 and 589,321, chinook at 7,698 and 15,098, chum at 246,144 and 134,958, coho at 78,588 and 28,290, and pink at 96,167 and 131,484. Sonar estimates of sockeye salmon were two to three times the ADF&G's escapement estimate based on aerial surveys and tower counts. The source of error was probably a combination of over-estimating the total number of targets counted by the sonar and by incorrectly estimating species composition. Because of the overlapped salmon run timing, estimating species composition appears the most difficult aspect of using sonar for

management. The study concluded that until some unbiased method of estimating species composition is developed, sonar estimates of salmon escapement do not appear feasible.

Because of the technical nature of sonar and the species apportionment issues, we feel sonar are the tool of last resort for estimating salmon escapement. When the idea of using a sonar was being investigated, weirs did not appear to be a viable option in the Togiak River. In 1990, ADF&G biologists surveyed the Togiak River above Pungokepuk Creek and identified some possible weir sites. From the literature and consultation with the Mitsubishi Corporation, the original designer of the floating weir, their weir would sink 1 foot below the waters surface when flow reached 5.5 ft/s. After surveying several sites and measuring flow in the Togiak River above the confluence with the Pungokepuk River, the ADF&G concluded a weir to be marginal (Tom Brookover, Alaska Department of Fish and Game, memo 1991).

With the continued development and deployment of the resistance board weirs in southwest Alaska, we felt a weir may be a viable tool for estimating salmon escapement on the Togiak River. The objectives were:

Phase I
1. Determine feasibility of installing a floating weir in the lower Togiak River.
2. Conduct stream profiles during low and high water flows; evaluate site data.

Phase II
1. Identify best possible sites; prepare project operation plan.
2. Order materials and fabricate weir; transport to site.
3. Install and operate project FY 2001 and 2002.

This report will describe the results of phase I to examine sites in lower Togiak River for installing a resistance board weir. Since the weir was not found feasible, this report will discuss some alternatives.

Methods

Phase I was the on-site investigation and project evaluation to determine if a weir is feasible to install and operate on the Togiak River. On May 5 and 6, 2000 biologists from the King Salmon Fishery Resource Office (KSFRO) and Togiak National Wildlife Refuge (Togiak NWR) visited the study site in the lower Togiak River. Stream profiles were measured in sites that appeared suitable for weir installation. The criteria were: 1) current flowed parallel to shore; 2) water depth allowed a person to wade across the stream; 3) substrate size was large gravel or small cobble (> 2 inches in diameter from visual inspection); 4) regular bottom with no abrupt troughs or trenches.

For the areas that met these criteria, we used a Precision Lightweight Global Positioning System Receiver (PLGR) to calculate latitude, longitude, and width. Depth was recorded with surveyor's rod at every 20 clicks (approximately 50-80 feet) of a surveyors hip chain as we crossed the river. Velocity was measured with a Price AA flow meter in current as strong as we could stand up in (about 3 ft/sec). Velocity was measured near the surface

to maximize the effect that the current would have on workers in the water, but does not represent the maximum velocity at the site. Substrate composition was estimated by visual inspection. Discharge data on the Togiak River from the Fish and Wildlife Service's Water Resources Division gauging station (Figure 1), approximately 18 river miles upstream of Togiak Bay, was used to evaluate seasonal river discharge, velocity, and depth.

The criteria for site selection are: the lands adjacent to weir site are available from local land owners for setting up a camp, the river is wadeable (3 foot or less in depth) at low water (April), and water discharge must be below 1 m^3/s per 4 foot of stream width (Ken Harper and John Tobin, Kenai Fishery Resource Office personal communication) between June 15 and September 15. The site also needed stable substrate to prevent erosion. As a rough indicator, substrate movement can be expected at 9 ft/s for 4 inch diameter substrate, 6.5 ft/s for 2 inch substrate, and 5 ft/s for 1 inch substrate (Alan Peck, Water Resources Branch, Personal Communication).

Results and Discussion

During the spring (May 5 and 6, 2000) staff from Togiak National Wildlife Refuge and King Salmon Fishery Resource Office measured stream profiles in lower Togiak River to identify possible weir sites (Table 1 and Figure 1) These dates correspond to the period after ice out but before snow melt when the river typically is at the lowest level during the open water season. At site 7, one of the more practical weir sites, we estimated the flow at 100 m^3/s (cubic meters per second). The average depth at low low water was 2.9 feet with a velocity of 3 feet per second and a maximum depth of 3.7 feet (Figure 2). The river was 433 feet wide. The practical guideline for installing a resistance board weir is for a person to be able to wade the river. The depth of 3.7 feet is slightly deeper than a person can wade but we could adapt installation techniques. The other critical element is the weir itself. The current design of resistence board weirs constructed with PVC conduit will begin to sink when discharge approaches 1 m^3/s per 4 foot panel (Ken Harper and John Tobin, Kenai Fishery Resource Office, personal communication). For site 7, 108 weir panels would be needed to span the river. Therefor, when the discharge exceeded 108 m^3/s, the weir would sink. Since we estimated the discharge at about 100 m^3/s at low water, the weir would be at near its capacity to remain fishable even during low flow periods with the current design.

The Water Resources Branch of the Fish and Wildlife Service has installed a water discharge gauging station upstream of site 7. They have provided preliminary river discharge data for May through September 1999 and May through June 2000 to assess weir feasibility. Based on gauge height (Figure 3), their data predict low summer flows in July to be twice the 108 m^3/s weir threshold. Based on estimated discharge and fish migration data from the King Salmon Fishery Resource Office sonar project in 1990, the weir would stay submerged most of the fish migration (Figure 3). In 1990, ADF&G staff conducted a similar feasibility study but did not have the hydrological data (Brookover, memo February 1, 1991). They concluded that the resistance board weir would probably have floatation problems during normal flows.

Table 1. Latitude, longitude, flow characteristics, and substrate description of potential weir sites on the Togiak River, Togiak National Wildlife Refuge, May 5 and 6, 2000.

Site	Lat (N)	Long (W)	Width (ft)	Avg. depth (ft)	Max. depth (ft)	Velocity (ft/sec)	Substrate [1]
1 [2]	59.15.590'	160.11.790'			>5.0		suitable
2	59.15.769'	160.11.980'	436	2.7	4.1	2.8	suitable
3	59.16.729'	160.12.021'	476	2.9	4.1	2.8	suitable
4 [2]	59.16.630'	160.11.520'			>4.0		suitable
5 [2]	59.18.070'	160.10.050'			>4.0		suitable
6	59.17.493'	160.10.443'	363	3.1	3.8	3.7	suitable
7	59.13.846'	160.11.378'	433	2.9	3.7	3.0	suitable
8 [2]	59.11.629'	160.16.279'					marginal - small

[1] Suitable substrate size was large gravel or small cobble (> 2 inches in diameter from visual inspection).

[2] No additional measurements because the depth exceeded workable depths or the substrate was too small.

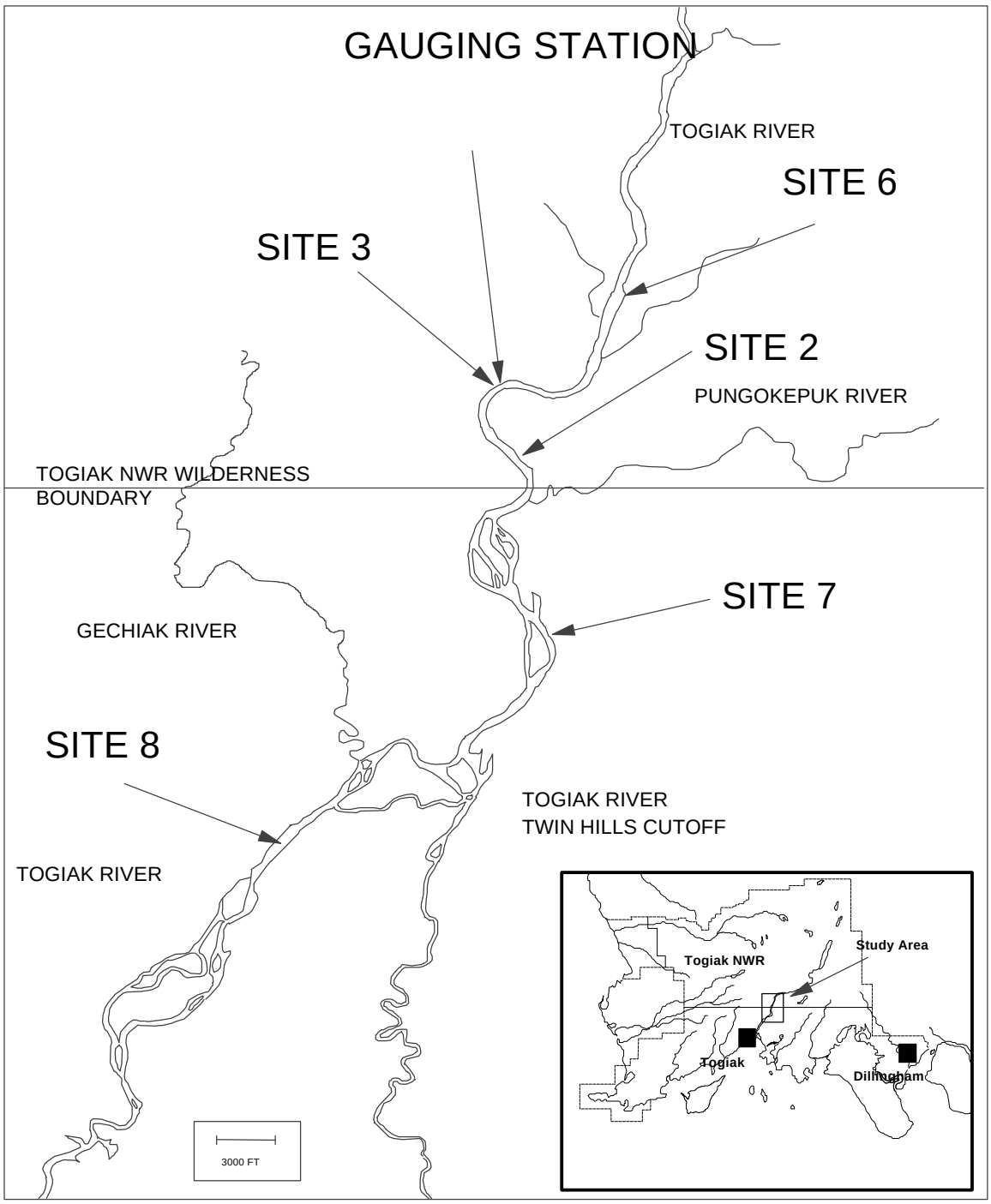

Figure 1. Location of sites surveyed for depth profile and substrate size on the Togiak River, Togiak National Wildlife Refuge, May 5 and 6, 2000.

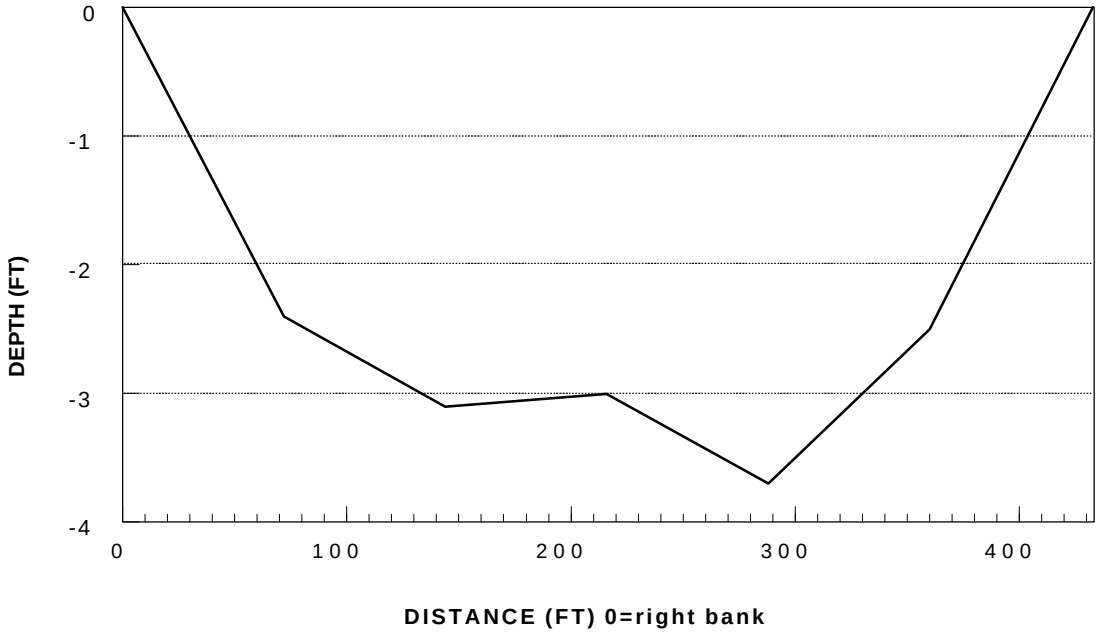

Figure 2. Depth profile at site 7 on the Togiak River on May 6, 2000. Total width of the site was 433 feet.

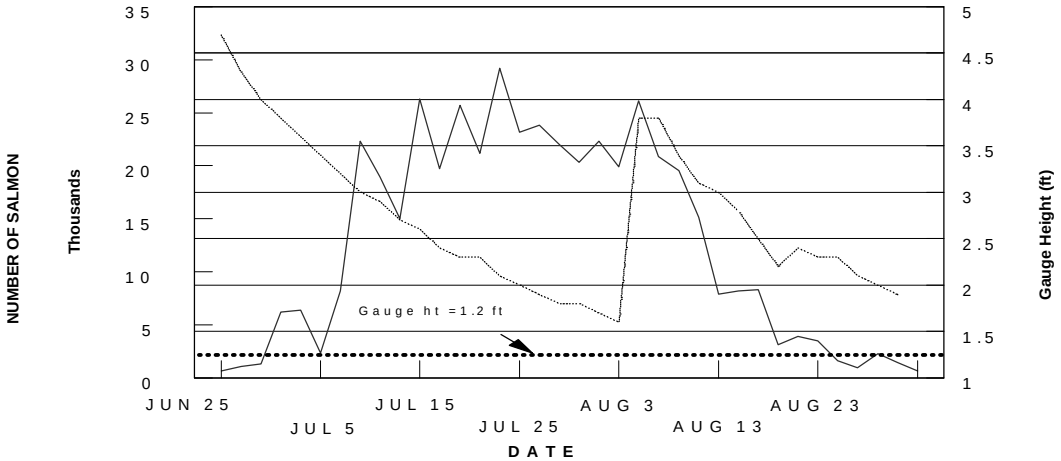

Figure 3. Run timing of all salmon species (solid line) in lower Togiak River from1990 sonar project compared to the 1999 gauge height (dashed line) on the Togiak River above the confluence with the Pungokepuk River. The weir would sink when the gauge height exceeds 1.2 ft (dark dashed line).

Bed load movement and erosion could damage the weir and would probably be of greatest concern during spring runoff. Typically, resistance board weirs are installed at low flows after breakup and before the spring runoff occurs. This strategy requires the weir withstand high spring flows. To minimize the potential damage to the weir, the resistance boards are not deployed. This allows the weir to be easily submerged. Once the water recedes in late June, the resistance boards can be set in place and the weir made fish tight. Ideally, the weir would be installed just before the salmon migration. However, river discharge would still be too high. Installing the weir prior to spring runoff makes it vulnerable to damage if flows are too great. While there are not any guidelines to suggest maximum flows, the peak flow during spring 2000 was more than 600 m^3/s. The potential for erosion and substrate movement are of great concern . As a rough indicator, substrate movement can be expected at 9 ft/s for 4 inch diameter substrate, 6.5 ft/s for 2 inch substrate, and 5 ft/s for 1 inch substrate (Alan Peck, Water Resources Division, Personal Communication). The substrate at site 7 is a mixture of cobble (2-4 inch in diameter) and gravel (about 1 inch in diameter). The peak river velocity during the spring runoff period near the bottom was 7.5 ft/s (Figure 4). About 1/3 of the channel exceeds 6.5 ft/s and would be vulnerable to erosion. We conclude that bed load movement is very likely and installing the weir in the spring before high flows will cause erosion and endanger the weir. In addition, the weir and weir rail will create turbulence that will lower the threshold where erosion occurs further increasing the risk of damage to the weir.

Conclusion

We feel installing a weir on the main stem Togiak River is likely to be unsuccessful because of high spring runoff. Even if the weir were installed after the spring runoff, it appears flows would exceed the flow threshold that sinks the weir for most of the season and we would miss a large proportion of the salmon run. The main stem weir idea should be abandoned and alternatives investigated. We feel that the salmon runs are such an important component to the lifestyle, culture, and traditions of Togiak Village and to the ecosystem that better escapement estimates for all salmon species is warranted.

Alternatives

There are several alternatives we feel should be examined; estimating escapement on one or two tributaries; conducting a mark/recapture estimate; operating a sonar on the mainstream; or increasing the frequency of aerial surveys. Each alternative has advantages and disadvantages.

<u>Estimating escapement on tributaries</u>. Estimating escapement on tributaries to the Togiak River could be accomplished through several methods including conducting tower counts, video counting, or installing weirs. Tributary estimates would provide and index of escapement similar to how ADF&G currently estimates sockeye salmon escapement. The current tower estimate includes only a portion of the sockeye salmon run. However, over time, the escapement estimate has provided a management index that is representative of the entire sockeye salmon run. Escapement estimates on tributaries would supplement the current tower count at Togiak Lake for sockeye salmon management while providing

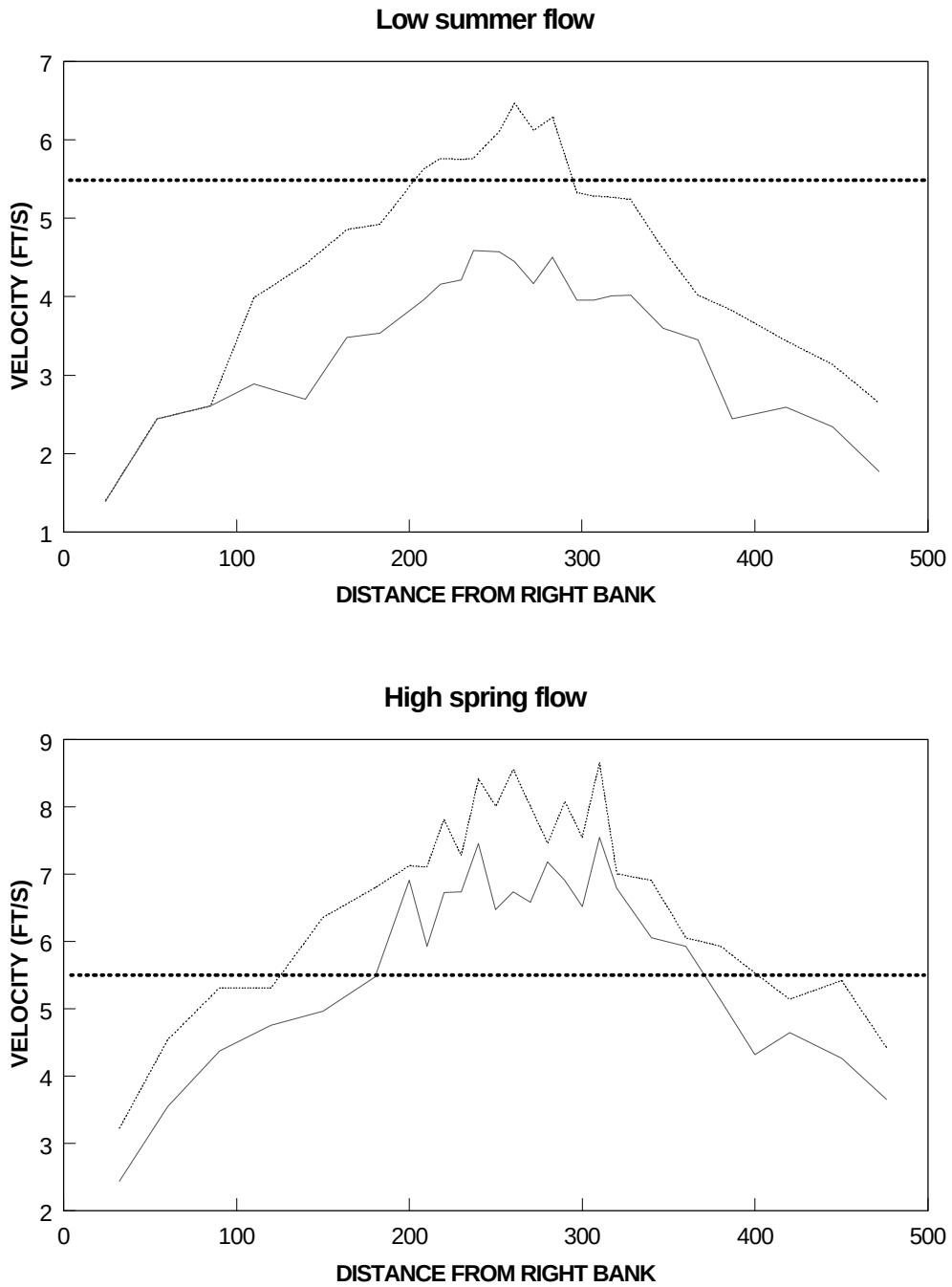

Figure 4. Velocity transect during high spring flow and low summer flow on the Togiak River above the confluence with the Pungokepuk River. The solid line shows the velocity near the bottom (measured at 0.8 of the depth). The light dotted line shows the velocity near the surface (measured at 0.2 of the depth). The heavy dotted line represents the level that the Mitsubishi resistance board weir sinks (5.5 ft/s).

similar information for other salmon species. The disadvantages include counts that will occur later in the season than a weir on the main stem. Also, the counts will only be a portion of the entire run and may or may not be representative of the entire run. Most of the chinook are main stem spawners so tributary estimates may not be a good method to count chinook (Jim Browning Personal Communication). Selecting the appropriate tributaries with good runs of chinook, chum, coho, and pink salmon will be important. It will take several years of escapement estimates to feel comfortable with the escapement estimates and how they represent the entire salmon run.

Weirs are the most direct method to estimate escapement. The advantage of installing a weir would be the ability to obtain an accurate and precise escapement estimate on that tributary. The weir installation and operation are also very feasible and should be able to operate through the coho season. Weirs would also give us the ability to collect biological data from fish. The annual operation cost of two weirs would be similar to the main stem weir cost. Initial startup cost would also be similar.

Counting towers could be operated on the tributaries similar to the weirs. The counting tower will provide a less precise escapement estimate compared to a weir. A tower is easier to operate than a weir since the weir is subject to flooding and erosion. Also, a tower does not hinder navigation. Purchasing and installing a tower is less expensive than a weir while manpower costs are similar.

An alternative to a counting tower would be to install video cameras on the tributaries. Other than the physical operation, the estimate would be the similar. The main advantage would be reduced manpower cost. Because of the reduced cost, more tributaries could be monitored. A disadvantage is the reduced reliability due to potential equipment failure and electricity requirements.

Mark/recapture estimate. The ADF&G is proposing or has conducted mark/recapture estimates on salmon using radio telemetry and partial escapement estimates (such as the tributary estimates explained in the previous paragraphs) in other river systems. Instead of an index of escapement, this would provide an estimate of each species total run size. As an alternative to radio telemetry, we feel genetic markers may be feasible to use as the marking part of the estimate. This would require establishing a genetic baseline for the drainage for each species. After the genetic baseline was established, the commercial and subsistence harvest would be sampled to estimate the proportion of each tributary stock in the entire run. The tributary salmon escapement estimates would used to estimate the complete run size. For a very simplified example, if 10% of the coho run caught in the commercial fishery originated from Gechiak River stocks and we estimated the coho run in the Gechiak River using a weir at 1000, then the entire Togiak River coho run size would be estimated at 10,000 fish.

The advantage of using genetic markers versus radio telemetry is the fish handling associated with implanting transmitters. Fewer live fish would be handled using genetic markers. A disadvantage of genetic markers is the potential for spawning fish to stray

from their natal stream. Straying would bias the estimate. Also, it may not be possible to distinguish between individual salmon stocks within the drainage.

Main stem sonar. The King Salmon Fishery Resource Office operated a sonar on the Togiak River upstream of the Pungokepuk for three years (Irving et. al 1995). Species apportionment is the greatest problem facing sonar operation. The sonar had good potential to count the total number of fish past the site. The sonar location would improve in season sockeye salmon counts since fish migrated past the site 2-5 days after entering the river. The counts included most of the salmon migrating in the Togiak River, except for fish entering the Gechiak and Pungokepuk rivers. Unlike a weir, the sonar also has the ability to operate in most flow conditions. The main disadvantage of the sonar is the inability to discriminate between various fish species. Gillnets are typically used to apportion the run by species. Togiak River has five salmon species, Dolly Varden, rainbow trout and whitefish that migrate past the site and would be counted by the sonar. Because gillnets are very biased by fish size, apportioning the run based on gillnet sampling is inaccurate. The initial cost of the sonar would be greater than the weir. Until all of the problems associated with sonar operation were worked out, a full time biologist would have to be assigned to project oversight. After project development, annual operating cost would be similar to the main stem weir.

Aerial surveys. Currently, ADF&G and Togiak NWR conduct aerial surveys of the drainage in July and September. The frequency of the surveys could be stepped up to provide more timely counts for the watershed. The main advantage of aerial surveys is the relatively low cost and the large area that can be surveyed. The disadvantages are that the counts are highly variable and dependent on observer, weather, and water conditions. As the main stem Togiak River is turbid except at lower flows, accurate counts will always be difficult. In addition, no ground crews are available to gather biological data. The tower counts for sockeye salmon at Togiak Lake would need to continue.

Preferred Alternative. We recommend using the mark/recapture alternative. While the use of genetic markers to apportion the catch of specific tributary stocks is highly experimental, two aspects of conducting this estimate will provide valuable management data even if the experiment fails. Specifically, we will generate escapement estimates for several tributaries. Also, we will establish the genetic baseline for the major salmon species in the drainage. The genetic information will be particularly valuable for Bristol Bay salmon management and has application to mixed stock management on the Alaska Peninsula and high seas intercept of these stocks.

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