U.S. Fish and Wildlife Service

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Alaska Fisheries Technical Report Number 81

King Salmon Fish and Wildlife Field Office
King Salmon, Alaska
April 2005

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Comparison of Counting Tower Estimates and Digital Video Counts of Coho Salmon Escapement in the Ugashik Lakes

Michael R. Edwards

Abstract

In 2001, the U.S. Fish and Wildlife Service King Salmon Fish and Wildlife Field Office began a counting tower project to estimate coho salmon *Oncorhynchus kisutch* escapement into the Ugashik lakes using standard protocols developed for sockeye salmon O. nerka. Because the coho salmon run size was much smaller than the sockeye salmon run, there was concern that the standard protocols may be biased for coho salmon. In 2002, we compared escapement estimates of coho salmon obtained from the counting tower using standard protocols to counts obtained from a video camera that recorded images of all fish that passed the site. Over the 152 hours that we sampled using both methods, we counted 478 coho salmon from the video files while the counting tower estimated 426 coho salmon. A sign test indicated a significant difference in the frequency of positive and negative differences between the two methods ($Z = 3.53$, $P < 0.01$). The overall tower estimate was only 52 fish less than the total video count, and the difference between the two methods did not exceeded five fish in 87% of the hourly comparisons. Recognizing the inherent variability associated with counting tower estimates, they appear to be an adequate management tool for obtaining baseline escapement data on coho salmon into the Ugashik lakes.

Introduction

Pacific salmon *Oncorhynchus spp*. are a key part of the ecosystems in the Bristol Bay region of Southwest Alaska. Salmon provide an annual food source for the people and wildlife of the region and nutrient enrichment for aquatic ecosystems (Kline et al. 1997). The subsistence, sport, and commercial fisheries of the region depend heavily upon salmon harvest. The majority of subsistence and commercial harvest is sockeye salmon *O. nerka*, and Chinook *O. tshawytscha* and coho *O. kisutch* salmon comprise the majority of sport harvest (ADFG 2002).

Determining salmon escapement is key to salmon management in Alaska (ADFG and Alaska Board of Fisheries 2001). Accurate escapement data allows managers to regulate harvest, determine annual run strength, and monitor long-term escapement trends. Salmon escapements are estimated with a variety of techniques including weirs, aerial surveys, sonar, mark recapture experiments, and counting towers. The monitoring technique used is typically determined by the species being studied, amount of acceptable error, and the physical properties of the habitat. In Bristol Bay, the use of counting towers to estimate sockeye salmon escapement began in 1956 as an alternative to large and costly weirs (Rietze 1957).

Bristol Bay sockeye salmon runs are among the largest in the world (Burgner 1991), with escapements as high as 20 million recorded in the Kvichak River system (ADFG 2001). Sockeye salmon spawning migrations usually occur in schools and as the number of migrants increase, these schools blend together forming an almost continuous band of fish (Becker 1962). The migratory behavior of sockeye salmon (e.g. schooling behavior and near-bank migration)

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allows their escapement to be estimated from counting towers at a level of acceptable accuracy. Counting tower estimates of sockeye salmon escapement were compared to weir estimates in the Egegik River and were within 13% of weir estimates (Rietze 1957, Spangler and Rietze 1958). Counting towers remain an effective technique for estimating sockeye salmon escapement and are currently used on eight river systems in Bristol Bay (Anderson 2000).

In Bristol Bay, counting tower escapement estimates for salmon species other than sockeye salmon are limited (Russell 1996; Weiland 1996; and Price and Larson 1999). Although counting towers have been shown to produce accurate escapement estimates of large sockeye salmon runs (Rietze 1957, Spangler and Rietze 1958), this may not be true for runs of smaller magnitude or salmon species with different migration patterns. The current method to estimate salmon escapement from a counting tower assumes that fish passage observed during hourly sub-sample counts is representative of the entire hour. With a small run size; there is concern that this assumption may not be met. We wanted to determine if using the identical tower methods (i.e., 10-min counts) from the 2001 coho salmon escapement estimate (Edwards and Larson 2004) would meet our management objectives. To verify that the tower protocols developed for sockeye salmon are not biased when used to estimate coho salmon escapement in the Ugashik lakes, we compared hourly tower estimates to counts of fish passage using digital video equipment.

The use of video technology in fisheries management is a rapidly evolving and promising technique with wide ranging applications (Irvine et al. 1991; Hatch et al. 1994; Hiebert et al. 2000; Otis and Dickson 2001; Faurot and Kucera 2002; Anderson et al. 2004; Hetrick et al. 2004). Video technology allows managers to collect high quality data from remote locations with fewer personnel. Digital video also provides images that can be reviewed numerous times without image degradation, are easily archived, defensible, and can reduce possible study impacts to the species being observed. In studies where visual counts are the technique of data collection, digital video has the potential to replace and or enhance current techniques. The objective of this study was to compare hourly counts of coho salmon obtained from video to corresponding hourly counting tower estimates.

Study Area

The Ugashik lakes are located within the Alaska Peninsula National Wildlife Refuge, about 120 km southwest of King Salmon, Alaska (Figure 1). The Ugashik lake system is comprised of an upper lake (22,300 ha) and a lower lake (19,200 ha) that are joined by a short channel called the Ugashik Narrows. The lake system is supplied with water from tributaries originating in the Aleutian Range to the east of the lakes. The lakes support populations of five species of Pacific Salmon with sockeye and coho salmon being the most abundant (ADFG 2002, Edwards and Larson 2004,). Resident species documented in the Ugashik lakes are Arctic grayling *Thymallus arcticus*, Dolly Varden *Salvelinus malma*, Arctic char *S. alpinus*, lake trout *S. namaycush*, and round whitefish *Prosopium cylindraceum* (Mecklenburg et al.2002). Fieldwork in 2003 documented the presence of pygmy whitefish *Prosopium coulterii*, a species believed to be present in the Ugashik lakes but previously undocumented (USFWS unpublished data). The counting tower site was located downstream of the outlet of the lower lake on the Ugashik River (Figure 1).

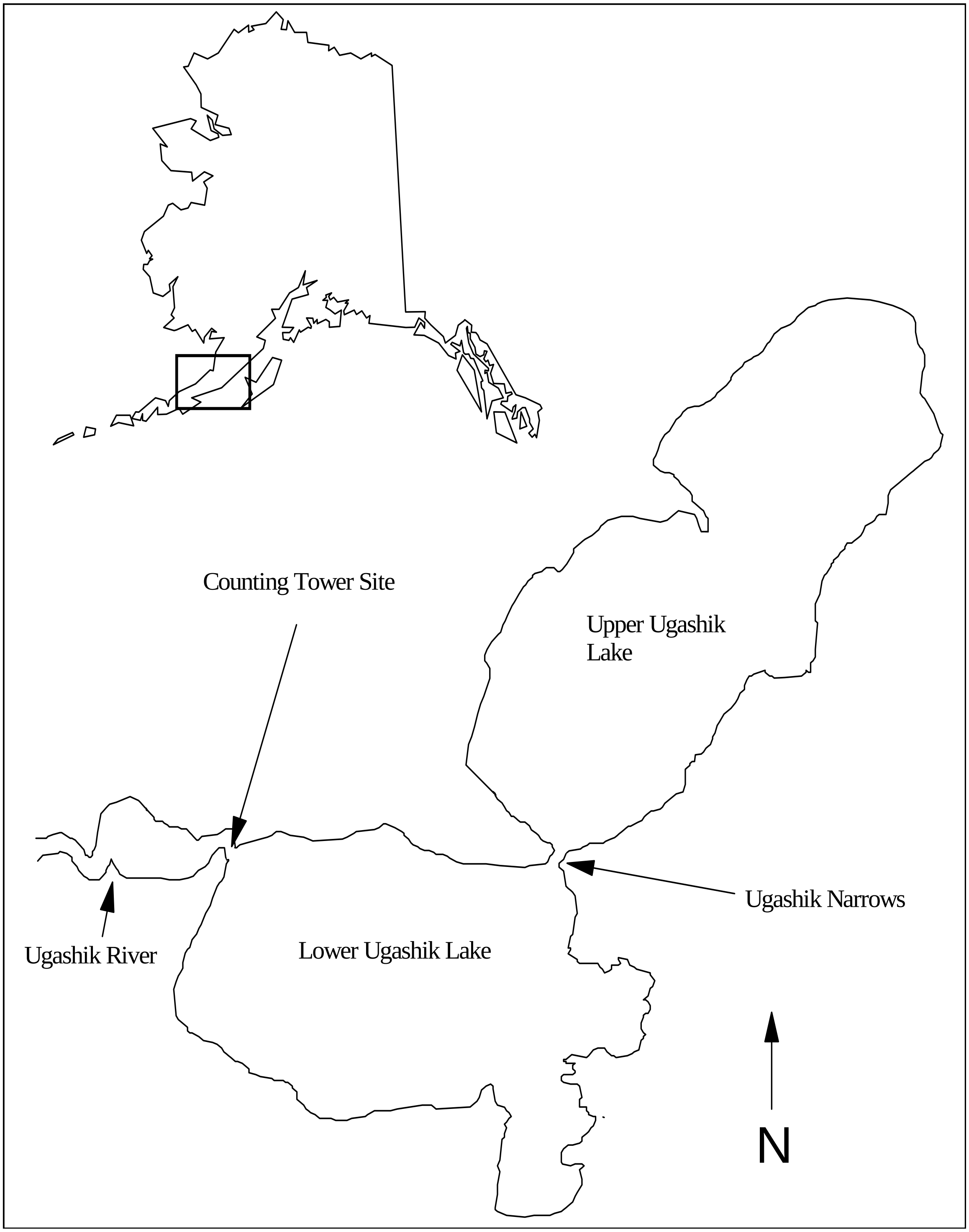

Figure 1. Location of counting tower site on the Ugashik River, Alaska Peninsula National Wildlife Refuge, 2002.

Methods

Coho salmon escapement into the Ugashik lakes was estimated using the counting tower procedures the Alaska Department of Fish and Game uses for sockeye salmon escapement (Edwards and Larson 2004). Counting tower procedure is to count fish passage for 10 minutes from each riverbank every hour of the day. These counts are multiplied by an expansion factor of six to estimate passage for the hour, and hourly estimates are summed to obtain the daily escapement (Anderson 2000).

From 27 August to 24 September 2002, digital images of fish passage at the tower site were recorded continuously between 10:00 and 15:00 hours each day. Attempts were made to collect images at other times, but tower orientation (i.e. facing southwest) resulted in unfavorable lighting conditions. The 2001 tower project (Edwards and Larson 2004) indicated that few coho salmon migrated at night; therefore, no video was recorded at night. Digital video images were collected with a single Supercircuit PC33C high-resolution video camera equipped with 5-20 mm zoom lens fitted with a circular polarizing filter. The camera was housed in a weatherproof case and mounted on a 5-m high pole located next to the right-bank facing downstream) counting tower. Digital images were recorded to an Alpha Systems Laboratory Digicorder 2000 Deluxe digital video recorder and a Lacie 120 GB external hard drive. Video files were one hour in length and date-time stamped for comparison to corresponding tower estimates. Video files were reviewed and the number of coho salmon migrating past the tower were counted and recorded. Two separate investigators reviewed video files and any disagreements on counts were resolved jointly. In both the tower and video estimates, fish moving downstream were subtracted from the count of fish moving upstream so the final count represented fish believed to enter the Ugashik lakes.

In making the comparisons between the two methods we assumed the following:

1. The video camera coverage was identical to that of the observer on the tower.
2. All fish migrating up the right bank were observed by the video.
3. Fish were not missed or incorrectly identified from the video.

We addressed the first assumption by positioning the camera such that the field of view covered the same section of river viewed by the observer on the counting tower (i.e., mid-river to the right-bank). We treated the video counts as absolute counts of fish passing the right-bank counting tower; it was not logistically feasible to test the second assumption. The third assumption was addressed by having two separate investigators review video files and any disagreements on counts or species identification were resolved jointly. We did not consider incorrectly identifying species as a major concern; the sockeye salmon run had ended and species other than coho salmon were in spawning color and easily identified. Again, the only way to validate assumptions two and three was to install a weir above the tower site, which was outside the scope of this study.

We compared hourly counts of coho salmon from video to the corresponding hourly tower estimate with the sign test (Zar 1999). The sign test compared the frequency of positive and negative differences between tower estimates and video counts. The null hypothesis of the sign test is that the frequency of positive and negative differences is the same (Zar 1999). A significant result from the sign test would indicate that tower counts were biased either high or low compared to the video count. Prior to performing the sign test, all data points in which there was no difference between the two methods were discarded (Zar 1999). Results were considered significant at an alpha level of 0.05 for the sign test.

Results

The counting tower was operated from 26 July to 24 September 2002, but the start of video operations was delayed for a month to coincide with the peak of coho salmon migration. We collected 152 hours of digital video from 27 August to 24 September, and an average of 5 hours of footage was collected each day. Video footage was not collected on 18 September due to mechanical problems. An estimate of 478 coho salmon was obtained from reviewing video files, and an estimate of 426 coho salmon was obtained from extrapolated tower counts for the same time period; the overall tower estimate was 12% less than the video estimate. Daily differences between estimation methods ranged from –103 to 100 (Table 1). Counting tower estimates were less than video counts 74 times and greater than video counts 36 times. Except for the 42 times when no fish were observed, the two methods never provided identical estimates of fish passage in any hour. Results of the sign test (StatSoft, Inc. 2004) indicated a difference in the frequency of positive and negative differences between the two methods ($Z = 3.53$, $P < 0.01$).

Discussion

Becker (1962) suggests that tower counts can only accurately describe fish passage occurring at the time of counting and that these counts are tied to the total number of migrating salmon such that the resulting daily estimate approximates the escapement. Becker (1962) also states that the accuracy of the estimate is dependant on the magnitude and fluctuations of the escapement. Fluctuations in the migration and magnitude of escapement are likely the cause of the difference observed between methods in this study. Personal observations and comments from the field crew that coho salmon entering the Ugashik lakes migrate in small sporadic groups support this conclusion. The presence of a technician on the tower may have influenced fish behavior (i.e., fish not passing while technician was on the tower) resulting in the tower estimate being negatively biased. However, if this were true, I would expect the overall difference between the two methods to be greater than what was observed.

Although counting tower estimates of coho salmon passage were less than concurrent counts obtained from digital video, I consider the difference negligible and not biologically significant for the collection of baseline data on this fish stock. The overall tower estimate was only 52 fish less than the total video count, and the difference between the two methods did not exceed five fish in 87% of the hourly comparisons (Figure 2). While this study did not compare counts from the entire 24-h counting period or from both riverbanks, the time periods and location covered incorporated typical patterns of coho salmon migration in the Ugashik River (e.g., sporadic and small in magnitude). Given that the overall difference between the two methods was small under these worst-case conditions, my inference was that the tower method was acceptable in obtaining an overall estimate of coho salmon escapement into the Ugashik lakes. Additionally, this study revealed high hourly and daily variation in tower estimates of coho salmon entering the Ugashik lakes. Bromaghin and Bruden (1999) suggest that regular, short duration monitoring of escapements will likely detect large changes in escapements while not detecting small changes occurring over short-time periods. Similarly, we observed high and low differences at the hourly level, but over 152 hours these differences began to cancel each other out resulting in a relatively small difference between the methods.

In this study we did not determine if the video equipment recorded the same fish as the counter on the tower during the hourly 10-minute sub-sample. Based on personal observation that glare did not hamper visibility during video operations and that water clarity was such that the substrate was visible from mid-channel to the right bank, we treated the video counts as absolute.

Video images were slightly diminished during high wind and heavy rain but at no time were the quality of video images reduced to the point we thought fish passage was undetected. In retrospect, comparison between the two 10-min counts should have been done during this study. However, I do not think the lack of comparison at this level detracts from the conclusion reached in this study.

This project also demonstrated the usefulness of video technology as a data collection tool in fisheries management. Advantages of using of video technology in projects where visual observations are the method of data collection include removal of instant decision making by observers, ability to review counts, cost savings, and archival of visual data. There are obstacles (e.g., data storage space, improving motion detection software) that remain before video cameras can replace humans on counting towers (Hetrick et al. 2004), but the potential uses of video technology in fisheries management are great.

Recognizing that there is inherent variability associated with counting tower estimates, their use in obtaining baseline escapement data on small coho salmon runs in the Ugashik lakes is an appropriate management tool. However, the level of accuracy obtained from counting towers may not be acceptable for all escapement monitoring, especially projects of small population size and with sporadic run timing. I recommend counting tower estimates of escapement on small runs be verified by an independent method before the results are accepted. If the variance associated with 10-minute counts is unacceptable, managers should consider adjusting the counting time interval as a possible way reduce the variance. In general, the usefulness of any population survey depends upon obtaining unbiased, or nearly unbiased, and precise parameter estimates in a cost-efficient, logistically feasible manner (Thompson et al. 1998). I consider using a counting tower to estimate coho salmon escapement in the Ugashik lakes a cost effective and logistically feasible method to collect baseline escapement data.

Table 1. Counting tower estimates, video counts, and number of hourly counts compared of coho salmon passage at the Ugashik River counting tower, 2002.

Date	Tower Estimates	Video Count	Difference	Counts
27-Aug	132	84	48	5
28-Aug	6	5	1	3
29-Aug	12	2	10	6
30-Aug	0	3	-3	6
31-Aug	18	10	8	6
1-Sep	6	4	2	6
2-Sep	30	27	3	6
3-Sep	0	31	-31	5
4-Sep	138	38	100	5
5-Sep	12	15	-3	5
6-Sep	0	5	-5	5
7-Sep	0	4	-4	6
8-Sep	12	4	8	6
9-Sep	0	15	-15	6
10-Sep	0	13	-13	6
11-Sep	0	8	-8	4
12-Sep	0	8	-8	5
13-Sep	0	103	-103	5
14-Sep	12	19	-7	5
15-Sep	-6	11	-17	6
16-Sep	30	17	13	6
17-Sep	0	5	-5	6
19-Sep	0	8	-8	4
20-Sep	0	4	-4	6
21-Sep	0	0	0	6
22-Sep	0	4	-4	6
23-Sep	24	14	10	6
24-Sep	0	17	-17	5
Total	426	478	-52	152

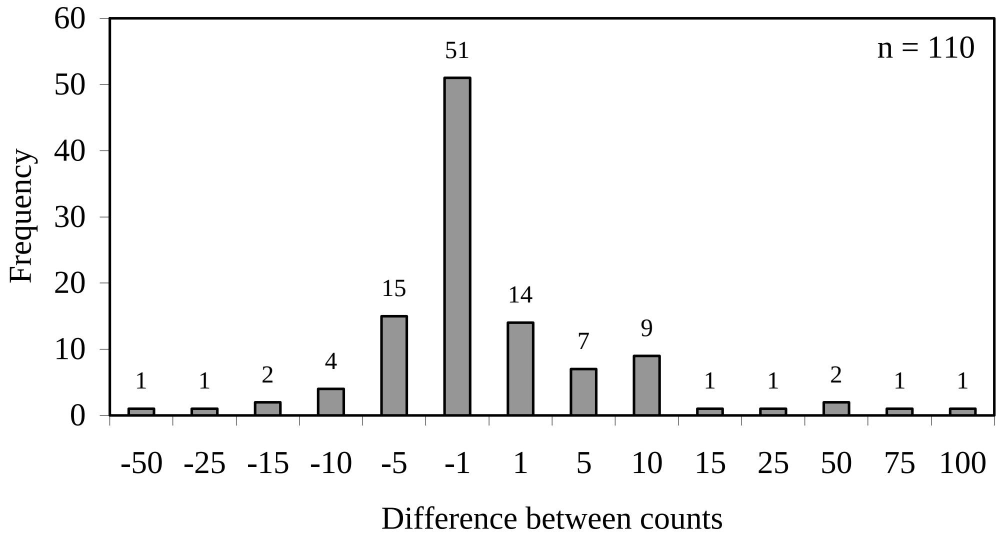

Figure 2. Frequency of differences between hourly counting tower estimates and video counts of coho salmon passage at the Ugashik River counting tower, 2002. A negative difference indicates the tower count was less than the video count.

Acknowledgements

I would like to thank the field crew who conducted the counting tower and video operations, Jeremy Carlson, Mike Oxner, Nick Neketa, and Ryan Kalmakoff. The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided funding support for this project through the Fisheries Resource Monitoring Program directly to the King Salmon Fish and Wildlife Field Office, as well as under Cooperative Agreement 70181-1-J334 with the Alaska Department of Fish and Game, and Cooperative Agreement 70181-1-J335 with the Bristol Bay Native Association. I would especially like to thank the staff at the King Salmon Fish and Wildlife Field Office for their support and assistance with this project.

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