CHIGNIK RIVER POST WEIR ESCAPEMENT ESTIMATION PROCEDURES

By

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ABSTRACT

Commercial fishing activities in the Chignik Management Area often continue after the weir at the Chignik River is removed for the season. A reliable daily estimate for the post weir period is needed to ensure that escapement goals and subsistence needs are met, and commercial fisheries can be conducted. An estimation procedure was developed that uses catch information, the time of season, and, if the fishery closes, previous escapement estimates. The resulting estimates were found to be more accurate than those of previous estimation methods and were used for management during the later portion of the 2001 commercial salmon season.

INTRODUCTION

The Chignik Management Area (CMA) is located on the south side of the Alaska Peninsula between Kilokak Rocks and Kupreanof Point and supports a large sockeye salmon *Oncorhynchus nerka* commercial fishery (Figure 1). The Chignik River system is the major sockeye salmon producer in the CMA and supports two distinct runs. The Chignik River system is composed of Black lake in the upper portion of the watershed which empties into the Black River and then into Chignik Lake (Figure 2). Chignik Lake discharges into Chignik Lagoon and the ocean through the Chignik River.

The Alaska Department of Fish and Game (ADF&G) annually operates a weir on the Chignik River to enumerate escapement into the Chignik River. The weir is generally operated from late May into early September after which budget restrictions and deteriorating weather conditions limit department projects at Chignik. During some years, high water levels during late August and September wash the weir out and persistent high water levels prevent weir reinstallation. This creates a situation in which commercial salmon fishing may still be underway, but management staff has no direct mechanism to ensure that escapement goals and subsistence needs will be met. Despite the limits of counting fish during the fall season, escapement continues through September and into October, as reported observations made by local residents and subsistence fishermen.

A post weir estimate of sockeye salmon escapement in the Chignik River prior to the end of the fishing season is essential for management of the commercial fall fishery as well as to ensure that the subsistence needs of local Chignik area villages are met. Several different methods of post weir escapement estimation have been utilized in the past including those using information on catchability of sockeye salmon passing through the fishery, inseason trends, historical timing, catch per unit effort, and time series analysis. Following examination of several of these methods, a method for estimating post weir sockeye escapement was developed for the 2001 season.

On August 20, 2001, a large portion of the Chignik River weir washed out due to high water conditions. During this time, most of the fishing fleet was engaged in a commercial fishery because the August sockeye salmon escapement levels were high enough prior to the weir washing out to allow extended fishing periods. Thus, the need to estimate post weir sockeye salmon escapement was required much earlier in the season than during most years.

Because the subject of this paper describes a new method, the format does not follow the standard scientific paper. The "model development" section will cover the methods as well as the results involved in the model development and the results of the model performance and comparison to the previously used method.

MODEL DEVELOPMENT

The only reliable information readily available for estimating escapement during the post weir portion of the season are the catches from the commercial fishery. Aerial surveys are not effective because of the relatively rapid passage of fish through the Chignik River, the deep water, and turbid conditions. Sonar equipment has been used at the Chignik River in conjunction with a partial weir with some success; however, a long term sonar project has not been tested and implemented.

To determine the relationship between catch and escapement, catch levels in the Chignik Lagoon Section (271-10) were compared with actual escapement from weir counts during July through the end of the season for 1996-2000. Catch from a particular date was compared with the following day's escapement because migration timing from the Chignik Lagoon to the weir is estimated to be one day (Conrad 1984).

The proportion of the Chignik sockeye salmon run (catch plus escapement) that escapes the fishery and makes it through the weir was calculated for each day that the fishery was open (during July to the day that the weir was pulled for the season), and will hereafter be referred to as the escapement proportion. To evaluate trends in the escapement proportion throughout the season, 2-week periods were averaged using a trimmed mean, which excluded values in the upper and lower 10% of the distribution to minimize the impact of outliers. The escapement proportions for each 2-week period were then graphed to investigate any temporal trends (Figure 3). During most seasons there was a general increase in the escapement proportion as the season progressed. These trends were then compared to the relatively small amount of escapement proportion information that was available for September, primarily from the 1996-98 seasons during which the weir was operated through the middle of September. In the years studied, it was found that the September escapement proportions were very similar to those found in late August, varying by only two to nine percent.

Because the Chignik weir washed out on August 20 in 2001, there were only three days during the late August time period that could be used to calculate the escapement proportion. The mean escapement proportion for the three days was 0.12. Because only three days were available to derive estimate, further investigation was warranted to verify the accuracy of this late August escapement proportion estimate.

The amount of increase in the escapement proportion from the early August to late August time periods (per day) during the 1996-2000 seasons was relatively consistent (range: 0.0 to 0.09; Figure 3) and averaged 0.05. The early August escapement proportion for the 2001 season was 0.07. This was added to the average increase of 0.05 which resulted in a late-season proportion of 0.12. This was similar to the estimate made from the limited late August data.

The escapement was calculated from catch numbers during late August and September during 1996-2000 for days that the fishery was open by multiplying the estimated escapement proportion from late August to the actual catch values. Initially, the escapement proportion was applied to the entire run (instead of just catch), but this method produced more variable results and tended to overestimate the actual escapement by a large amount. Therefore, the escapement was estimated by using catch only, which was a better index of fish passage.

To further increase the accuracy of the model especially toward the end of the season, an increasing estimate of fish was subtracted from the estimate as the season progressed. The "increasing trend integer" (ITI) was set to begin in August and increase linearly through the end of the season and was subtracted from the escapement estimate to reflect the decreasing trend of fish passage as the season progresses. The size of the incremental increase and initial magnitude of the ITI was also established using the Solver function in Excel™ by minimizing the errors between the actual escapements and estimated escapements. The resulting estimate will be smaller late in the season even when calculated using the same variables (ie. catch numbers). This reflects the decreasing amount of fish toward the end of the season.

Parker and Rogers (1983) found that the catchability of sockeye salmon in the Chignik Lagoon becomes highly variable when fewer than 10 permits were fished. For the purposes of this analysis (both in model development and implementation), all fishing days when 10 permits or less were fished were treated as a closure day.

Escapement estimates for days in which the fishery was closed or was considered a closure day due to less than ten permits fished, was made using the escapement estimate from the previous day. The previous day's escapement was multiplied by a fixed number (hereafter referred to as the growth factor) to simulate the increase in escapement due to the reduced or absent fishing pressure. The growth factor was estimated using the Solver function in a Microsoft Excel™ spreadsheet by minimizing the error between actual and estimated escapement during the periods of analysis (1996-98, 2000).

The time period used for this analysis, August 1 through the end of the season, was selected because the timing of the run is usually exhibiting a downward trend throughout this period. Because the 1999 season exhibited extremely high catch rates due to a record run and is considered atypical, data from the 1999 season was not used to estimate the model parameters. The growth factor was estimated at approximately 1.8. In other words, escapement for a day corresponding to a closure day was estimated by multiplying the previous day's escapement estimate by 1.8.

During periods of fishery closure, the model estimated an increase in escapement as is observed in reality. However, because long-term increases are not realistic, the growth factor was applied to a maximum of three days of fishery closure, after which, the escapement was estimated by subtracting the ITI from the previous day's escapement. This results in three days of increasing escapement estimates after which escapement slowly decreases until more catch information is available.

For clarity purposes, the model described above will hereafter be referred to as the Escapement Proportion Estimator (EPE).

Model Performance

To evaluate the predictive power of the EPE model, actual weir escapement counts were compared with estimates derived from the model for August 1 through the date that the weir was pulled each season during 1996-2000. The model provided reasonably accurate escapement estimates (Figures 4-9). Total escapements were generally underestimated during the time period studied (Table 1). The difference between estimated and actual escapements varied from 8,000 to 39,000 sockeye salmon during years with total escapements of 48,000 to 112,000 sockeye salmon during August 1 through the end of the season (Table 1). The model tended to underestimate large spikes in escapement (Figures 4-9), which was the cause of the majority of the differences between actual and estimated escapements. The underestimation of large escapements, however, provided a conservative approach for commercial fisheries management.

Model Comparison

The EPE model was also evaluated by comparing it's estimates against those obtained from the previously used method. During recent seasons, escapement estimates were made by calculating the ratio of catch to the next day of escapement during a time when the weir was in. The ratio was then applied to the catch after the weir was out to estimate escapement. Hereafter, this method will be referred to as the Catch Ratio (CR) method. The CR method had no means to calculate escapement during a fishery closure. Actual observations and ancillary data were used to estimate escapement during closure days.

To standardize the comparison, only those days in which a fishery occurred were used to compare estimates. A period of two weeks beginning August 1 was used to establish the catch to escapement ratio for the CR method for the 1996 through 2000 seasons. The period of estimate comparison was from mid August (right after the time period used to establish the catch to escapement ratio) until the time that the weir was pulled for the season. The estimates were then compared to actual weir counts during the same time period (excluding days that corresponded to fishery closures).

In all seasons investigated, the EPE method was found to be more accurate than the CR method (Table 3). Both estimates consistently underestimated the actual escapement.

2001 Season

Escapement estimates for the 2001 season were calculated from August 20 though 31 and totaled 29,106 sockeye salmon (Table 2). There was only one day during this time period which was closed to commercial salmon fishing. While there was a slow decrease in escapement estimates during the estimate period, the run appeared to be continuing at fairly strong levels during the later part of August. The estimated escapement averaged over 2,300 sockeye salmon per day during the last week of August despite consistent fishing pressure in the Chignik Lagoon. Despite the fact that no estimates were made after August 31, it is likely, given the rate of escapement and cessation of fishing effort, that the desired escapement of 25,000 sockeye salmon during September was achieved. Harvests in the Chignik Lagoon during that week totaled 208,722 sockeye salmon.

DISCUSSION

Model Characteristics

The EPE model was not intended to estimate escapement for extended periods of fishing closure (>three days) because the primary data used for estimation are catch. The longer the time between fishing periods, the less accurately the model estimated escapement.

While limited by catch data availability, the EPE model seems to reasonably predict escapement levels. The estimates for the growth factor, ITI, and escapement proportion may become further refined as additional seasons provide more information specifically concerning the later portion of the season. To effectively evaluate the EPE model's performance during the later portion of the season, weir counts must be available during September as the commercial fishing patterns and, perhaps, fish migrations change during the late season.

The EPE method (as well as the old method) generally underestimated large spikes in escapement (Figures 4-9) which contributed to most of the error in the estimates. The day-to-day accuracy of the EPE was generally good (Table 2), but since the large peaks in escapement during fishery closures were based on the previous day's escapement (not a real index of abundance), they remain difficult to predict.

One of the advantages of the EPE method over some other of the older methods are a result of the escapement proportion parameter model being derived from inseason trends. For instance, many other estimation procedures used some sort of fixed proportion of catch to estimate escapement. In cases of abnormal harvests, such as during the record 1999 season, those estimation procedures did a poor job of estimating the escapement. With the method presented here, the escapement proportion is established annually depending on the performance of the fishery and seasons with strange harvest patterns, such as the 1999 season, could be reasonably estimated (Figure 7).

2001 Season Estimates

During the 2001 season, estimates of Chignik escapement were calculated as verbal catch information became available (Table 2) from August 19 through 31, when the commercial fishery ended. Since the model tended to be the most accurate during fishery openings, and there was only one closure day during the period, the estimates produced are believed to be relatively accurate. The estimated escapement during this time period was 29,106 sockeye salmon (Table 2) and the estimation procedure was discontinued after August 31 because there was limited commercial fishing effort for the rest of the season. Without any significant commercial fishing effort, the model estimates for the entire month of September would be based on the last day of harvest and not believed to be accurate.

Postseason Estimates

Long-term time series analysis has been used to estimate post weir escapement especially after the commercial fishery has ended for the season (I. Vining, ADF&G, personal communications). Over a shorter time frame, as is the case for specific day to day commercial fishery management action, time series analysis is not suitable. Because time series analysis uses the entire seasons catch and escapement data set to estimate each daily post weir run estimate, any given daily estimate may not be indicative of the relative number of fish that are present on that day.

A time series analysis was attempted to estimate the total sockeye salmon escapement after the weir washed out in the 2001 season. Unfortunately, since there was no significant decrease in the run size prior to the weir washing out, the time series analysis results did not show a decrease in run size toward the end of the season and was, therefore, unreasonable (Vining 2001). As a result, no postseason estimate was calculated for sockeye salmon escapements into the Chignik River after September 1 for the 2001 season. However, reports from subsistence fishermen and the level of catches and escapements at the end of August, indicate that the supplemental escapement objective of 25,000 sockeye salmon for subsistence purposes was likely met.

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Parker, S.S. and D.E. Rogers. 1983. Chignik Sockeye Studies. Annual Report – Anadromous Fish Project. FRI-UW-8404. University of Washington.

Conrad, R.H. 1984. Management applications of scale pattern analysis methods for the sockeye salmon runs to Chignik, Alaska. Alaska Dept. Fish and Game, Tech. Data Rpt. No. 76.

Vining, I.W. 2001. Unpublished Memorandum to Patti Nelson. "Post-weir escapement for the Chignik system". Dated November 9, 2001.

Table 1. Chignik weir escapement and EPE modeled escapement August 1 to the end of the season (EOS), modeled escapement, 1996-2000.

Year	Escapement through weir August 1-EOS	EPE Escapement August 1-EOS	Total Difference (model-actual)	Average Daily Difference
1996	110,088	72,052	-38,036	-809
1997	111,397	72,748	-38,649	-805
1998	89,293	60,709	-28,584	-635
1999	89,928	53,489	-36,439	-1,104
2000	47,556	39,588	-7,968	-421

Table 2. Chignik Lagoon catch, weir counts prior to wash out, and modeled escapement, 2001.

Catch Date	Lagoon Catch	Escapement Date	Weir Counted Escapement	EPE Escapement
1-Aug	0	2-Aug	4,922	2,075
2-Aug	0	3-Aug	6,187	3,725
3-Aug	0	4-Aug	6,846	6,696
4-Aug	6,508	5-Aug	8,529	764
5-Aug	14,054	6-Aug	1,442	1,650
6-Aug	11,699	7-Aug	755	1,373
7-Aug	12,006	8-Aug	742	1,410
8-Aug	12,323	9-Aug	539	1,447
9-Aug	12,395	10-Aug	660	1,455
10-Aug	6,949	11-Aug	682	816
11-Aug	12,365	12-Aug	826	1,452
12-Aug	11,315	13-Aug	837	1,328
13-Aug	18,822	14-Aug	1,032	2,210
14-Aug	0	15-Aug	8,464	3,911
15-Aug	0	16-Aug	20,014	6,975
16-Aug	22,622	17-Aug	5,379	2,656
17-Aug	15,335	18-Aug	1,127	1,800
18-Aug	14,928	19-Aug	1,506	1,753
19-Aug	14,293	20-Aug	Weir washed out	1,678
20-Aug	0	21-Aug		2,924
21-Aug	23,667	22-Aug		2,779
22-Aug	27,205	23-Aug		3,194
23-Aug	20,149	24-Aug		2,365
24-Aug	28,434	25-Aug		3,338
25-Aug	17,899	26-Aug		2,101
26-Aug	16,381	27-Aug		1,923
27-Aug	19,430	28-Aug		2,281
28-Aug	16,557	29-Aug		1,944
29-Aug	21,560	30-Aug		2,531
30-Aug	17,440	31-Aug		2,047

Table 3. A comparison of the EPE method with the previously used escapement estimation method versus actual escapement, 1996-2000.

Year	Estimate Period	Actual Escapement [a]	EPE Escapement [a]	Old Method Escapement [a]
1996	8/15-9/16	66,362	23,024	21,869
1997	8/15-9/17	43,720	31,174	29,356
1998	8/16-9/14	38,360	22,114	19,200
1999	8/15-9/2	31,208	24,850	22,463
2000	8/18-8/30	19,213	13,100	10,571

[a] The escapement and estimates do not include days corresponding to fishery closures.

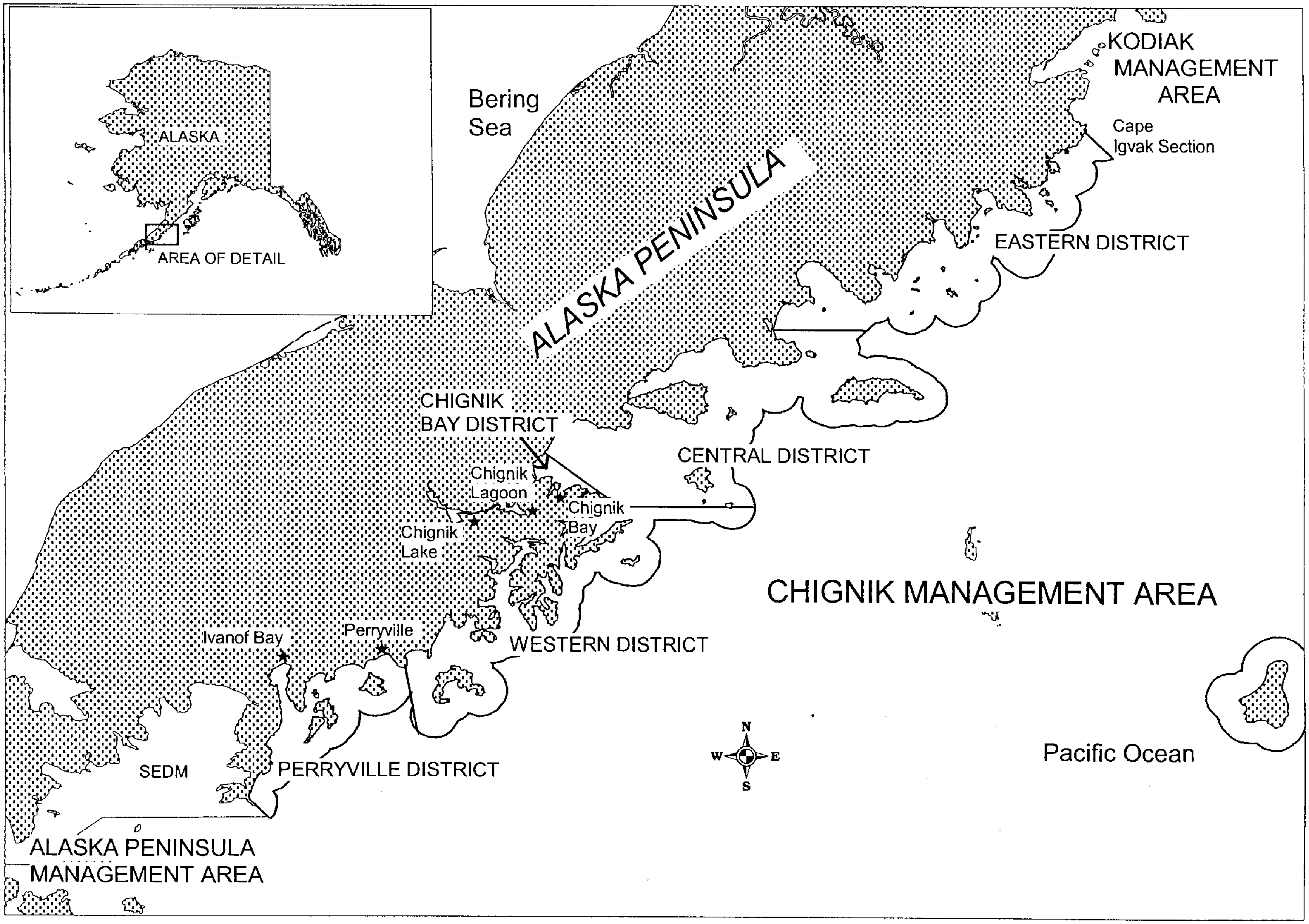

Figure 1. Map of the Chignik Management Area.

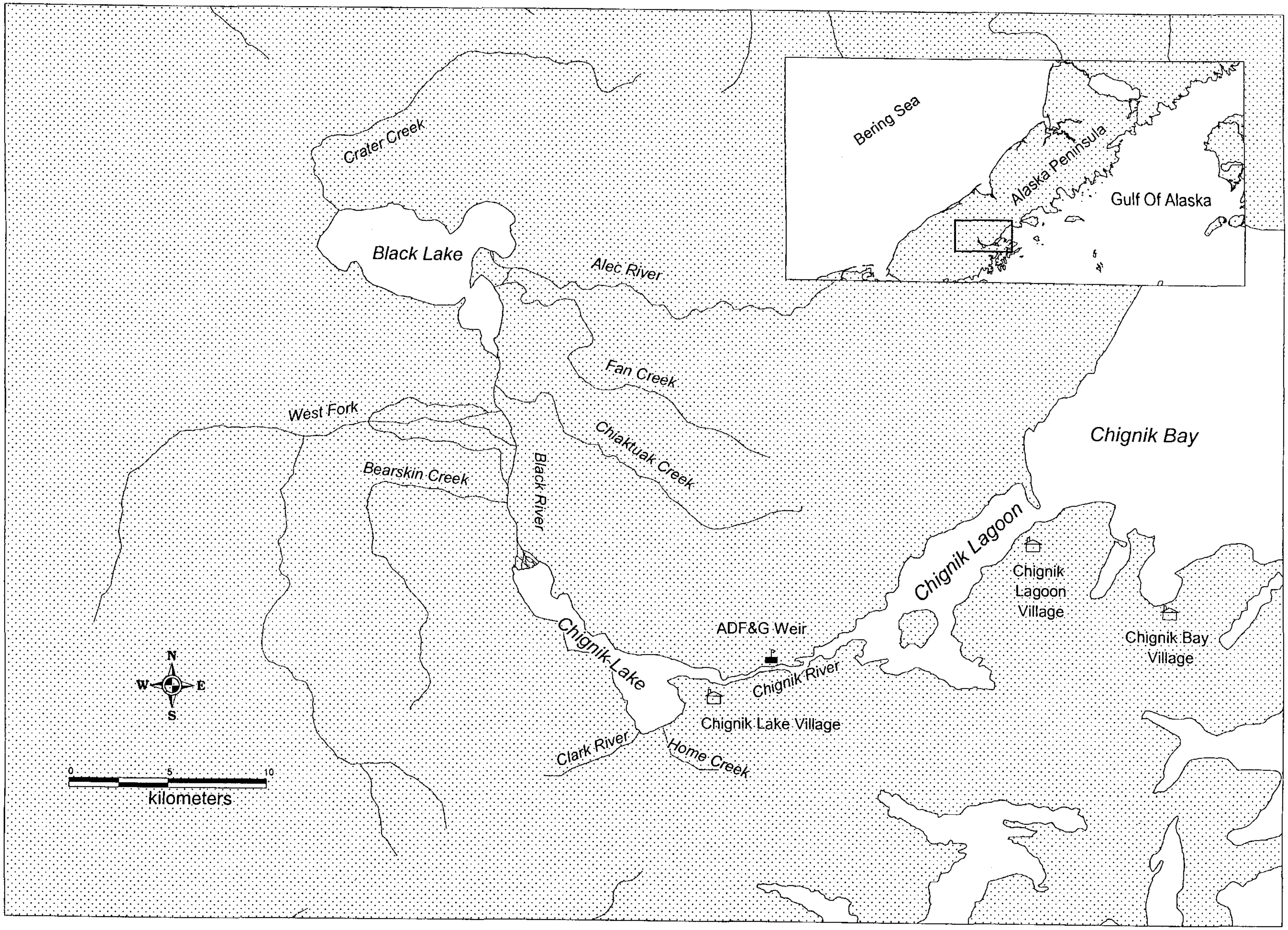

Figure 2. Map of the Chignik watershed including Black and Chignik Lakes.

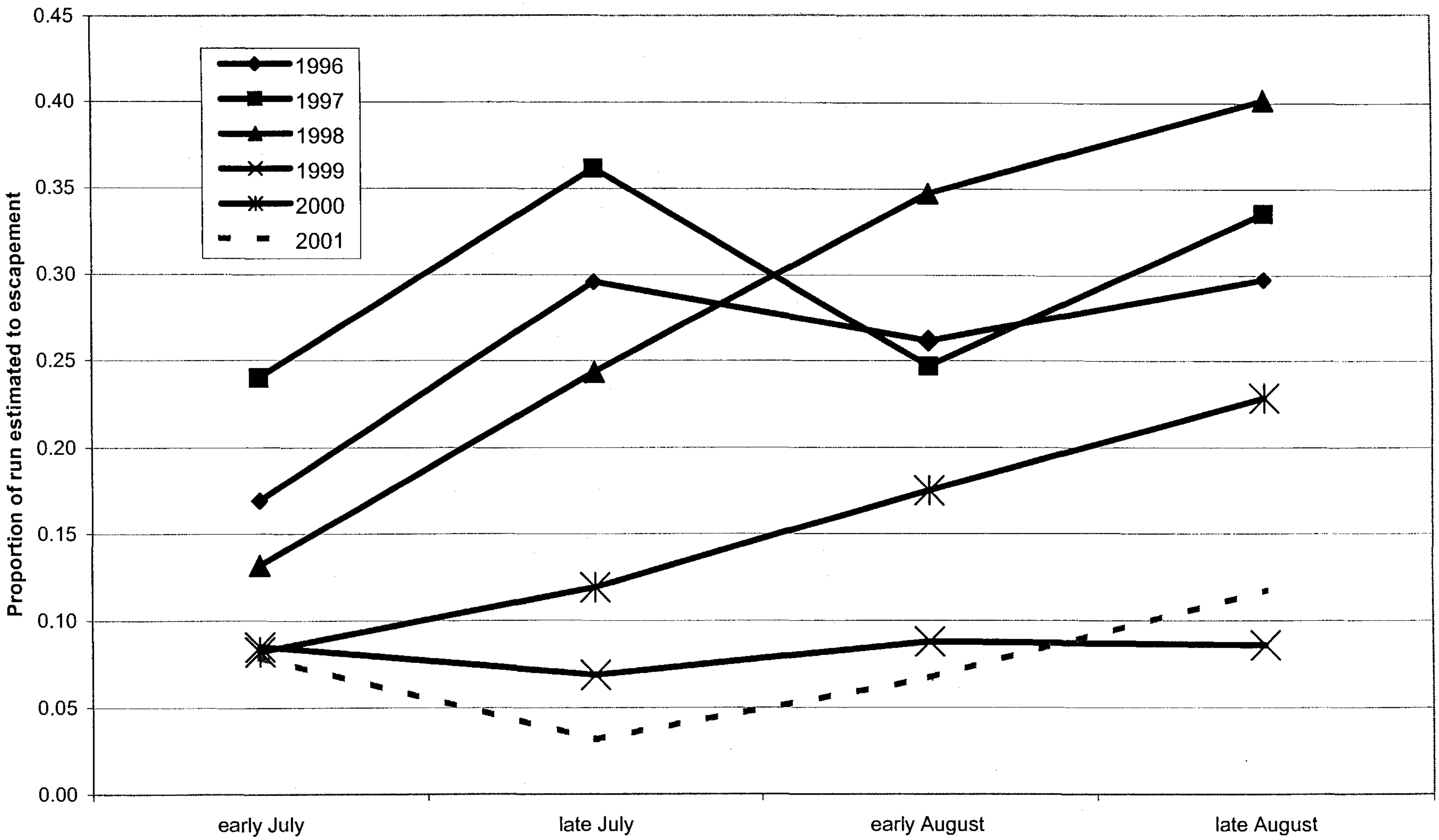

Figure 3. Escapement proportion of the Chignik River sockeye salmon run, July-August, 1996-2001.

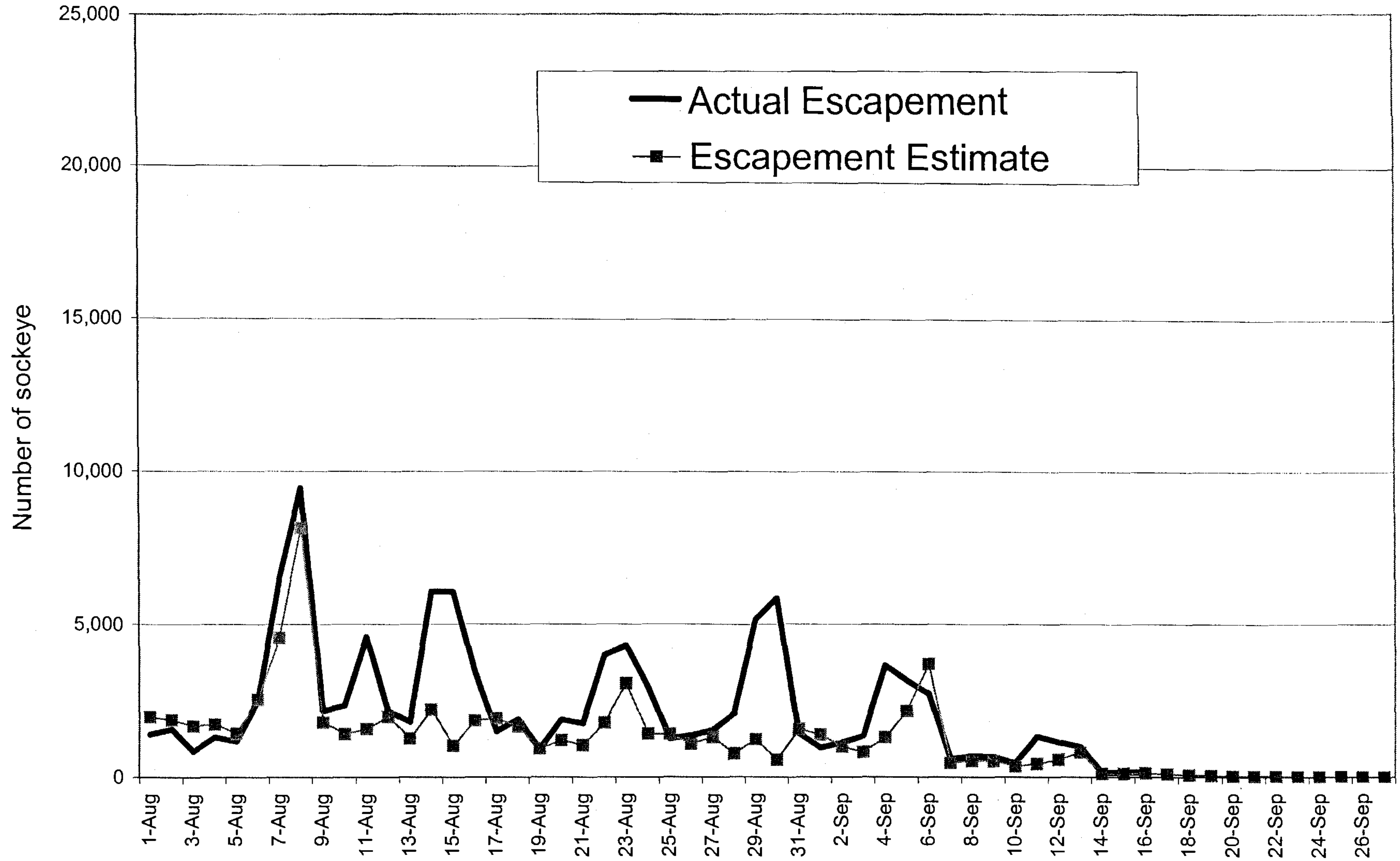

Figure 4. Actual weir counts and EPE modeled escapement by day, 1996.

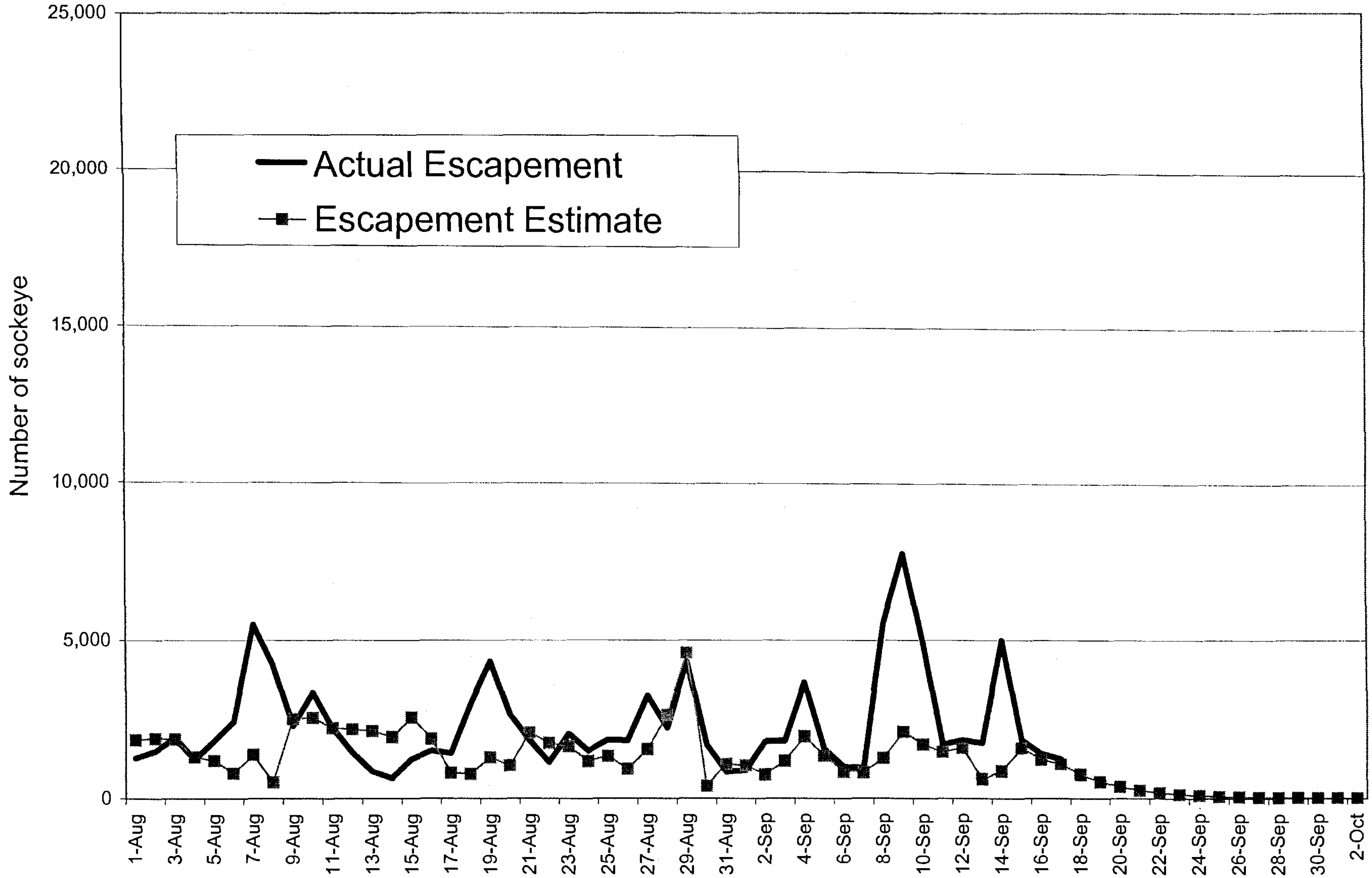

Figure 5. Actual weir counts and EPE modeled escapement by day, 1997.

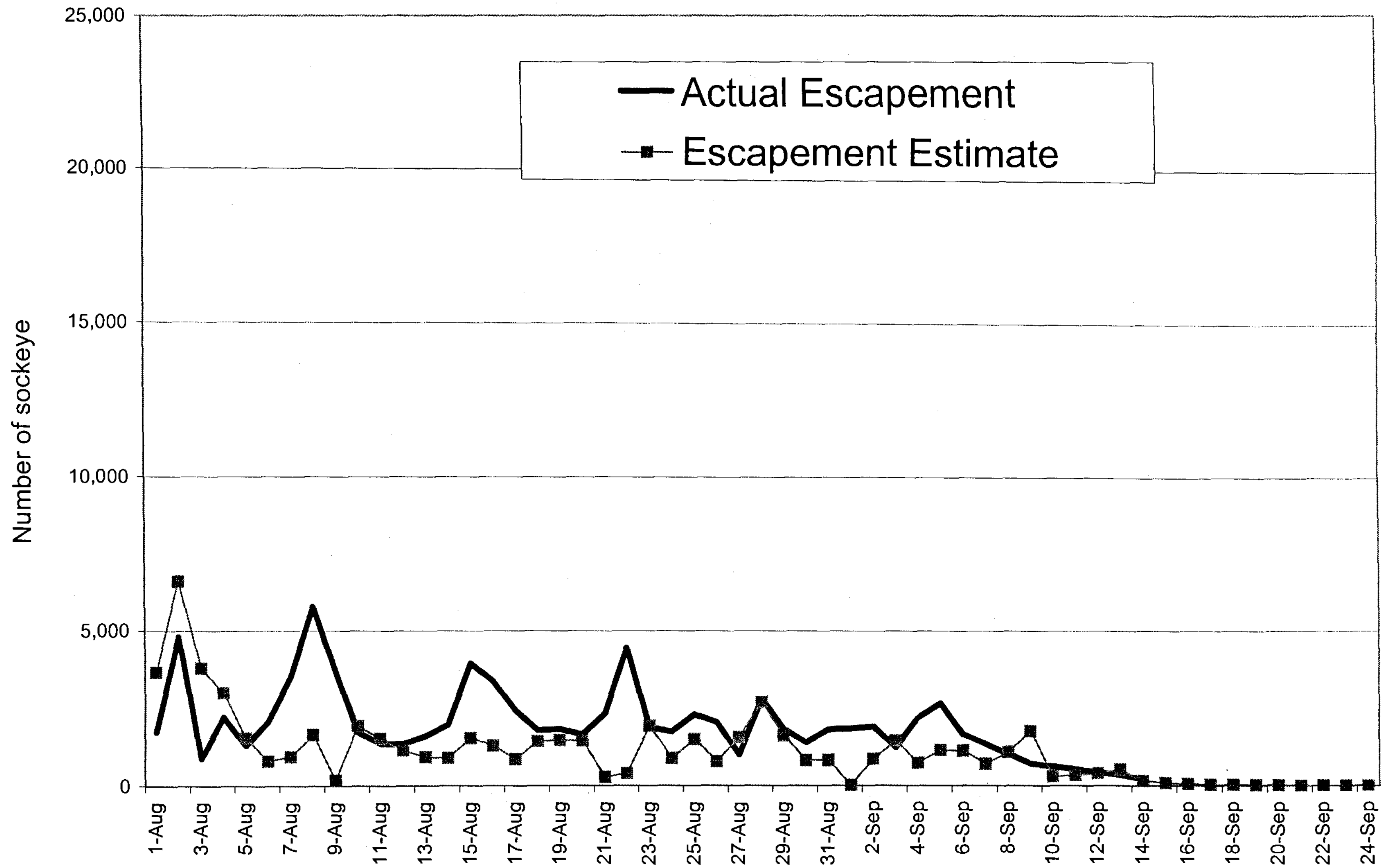

Figure 6. Actual weir counts and EPE modeled escapement by day, 1998.

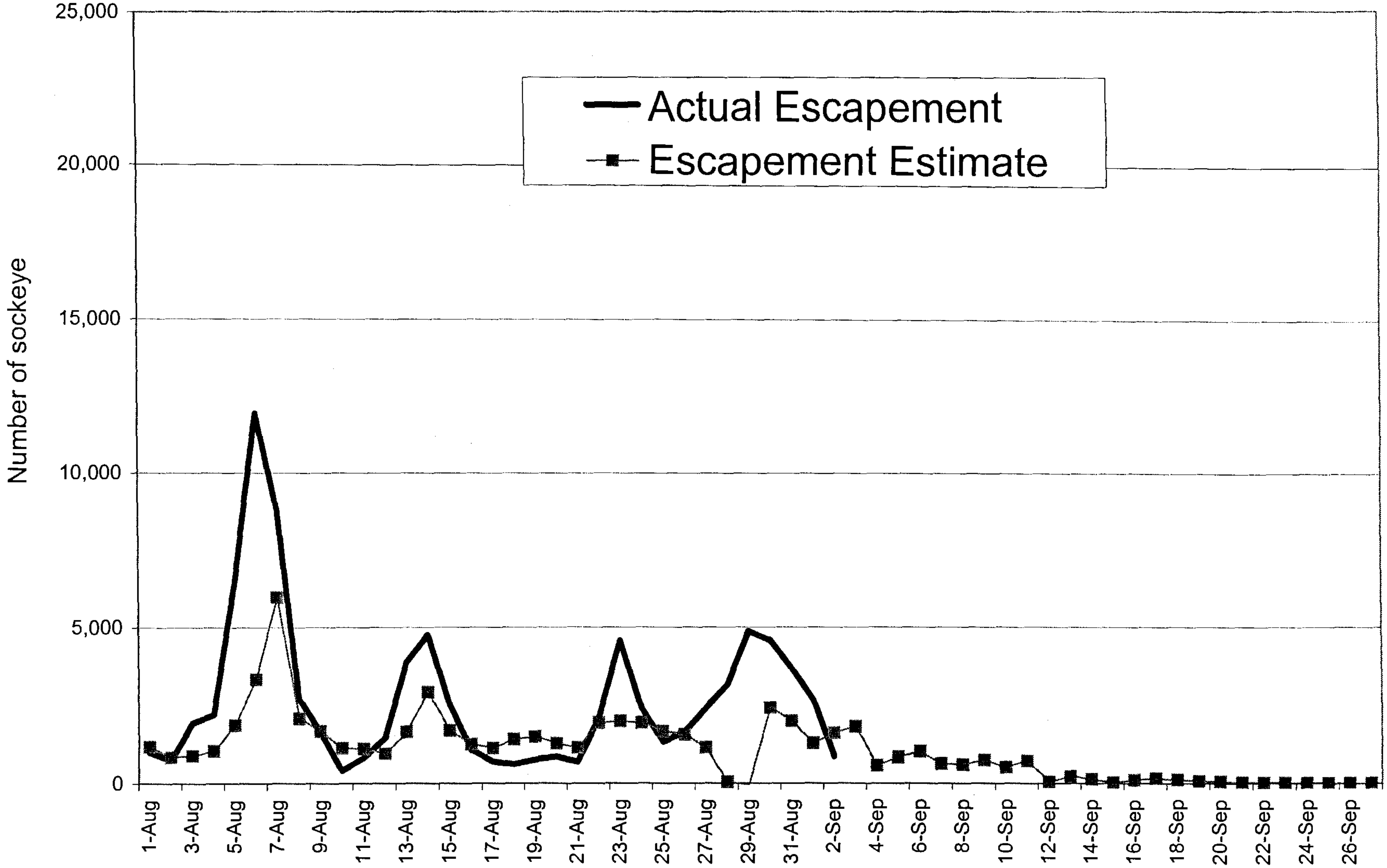

Figure 7. Actual weir counts and EPE modeled escapement by day, 1999.

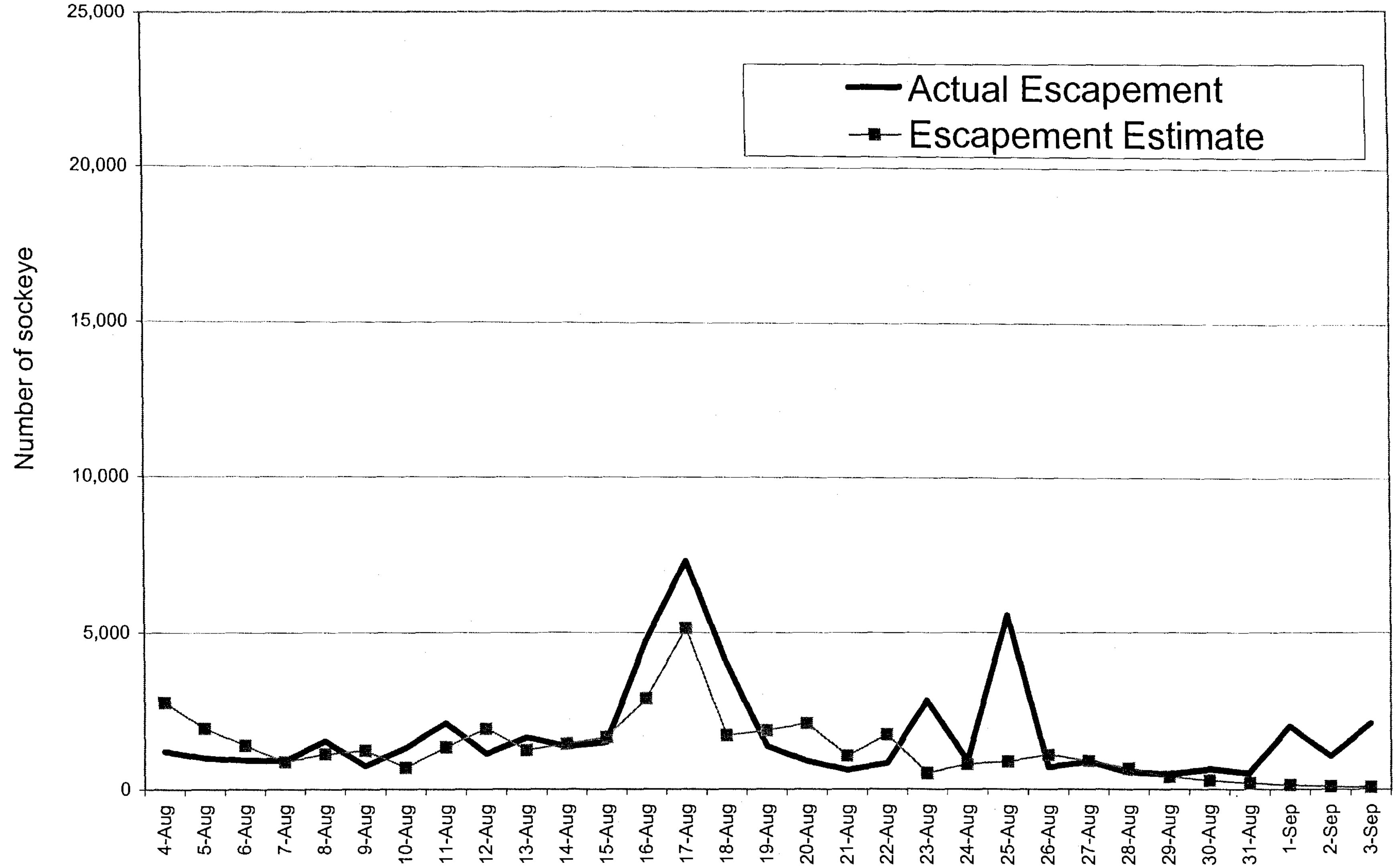

Figure 8. Actual weir counts and EPE modeled escapement by day, 2000.

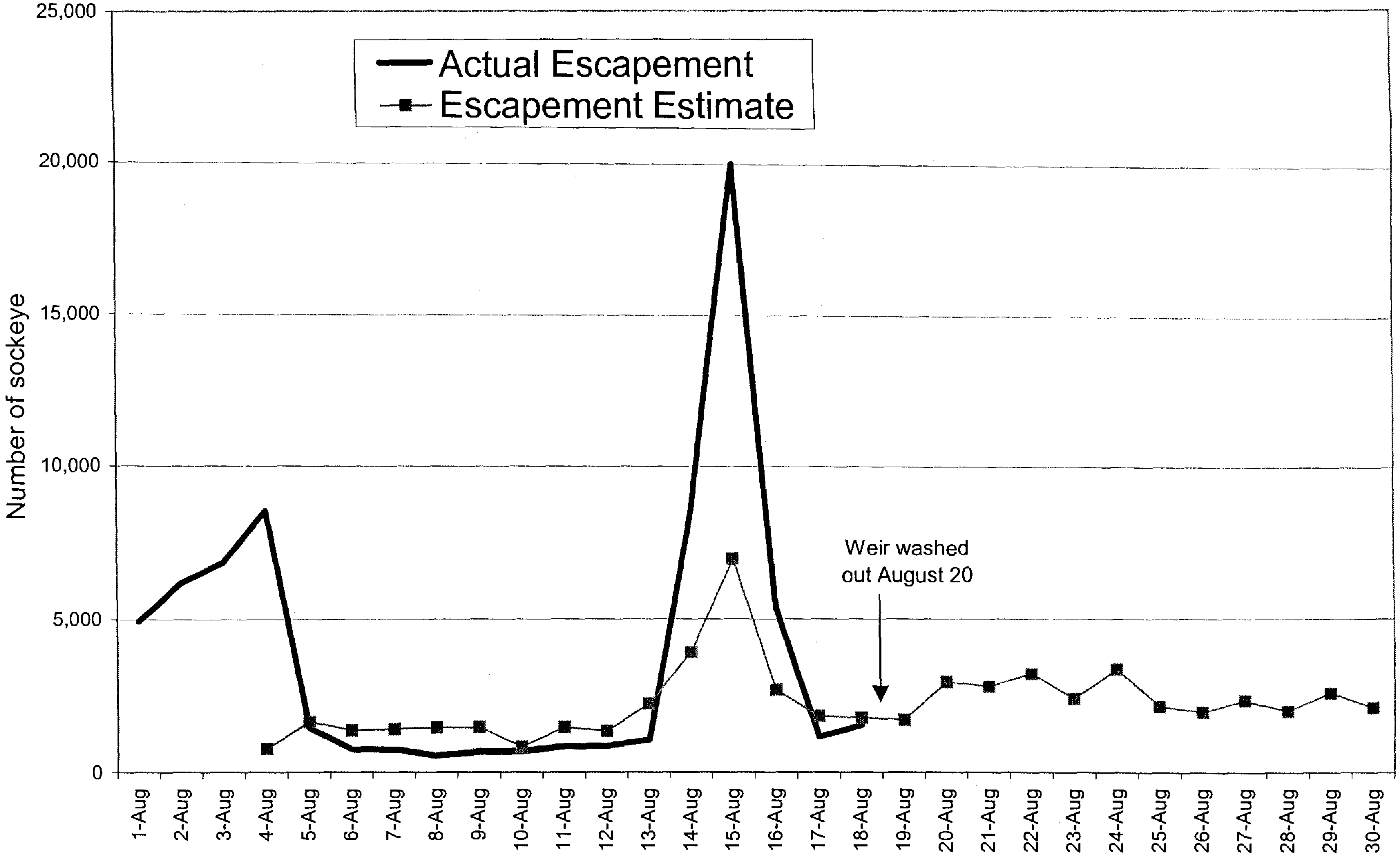

Figure 9. Actual weir counts and EPE modeled escapement by day, 2001.