COUNTING TOWER PROJECTS

IN THE BRISTOL BAY AREA, 1955-1999

By Cindy J. Anderson

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INTRODUCTION

Counting towers have been used to enumerate sockeye salmon *Oncorhynchus nerka* escapements in the Bristol Bay area of Alaska since the early 1950s (Figure 1). When combined with commercial catch and age class information, the escapement data allow biologists to estimate spawner-recruit relationships. Knowledge of such relationships is essential if biologists are to manage the commercial harvest of sockeye salmon on a maximum sustained yield basis.

The purpose of this report is to compile and review all Bristol Bay historical tower counting projects and data. This information was collected from file archives as well as data presented in published annual reports of the United States Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADF&G). The most recent data collected from towers is also presented in this report.

PROJECT HISTORY

Prior to Alaska achieving statehood, commercial fisheries in Bristol Bay were managed by the U.S.F.W.S. In order to obtain sockeye salmon escapement information, large weirs were installed in the major river drainages that supported sockeye salmon. These weir projects were very costly; they required large pieces of equipment, crews of up to a dozen seasonal employees and supplies to feed and lodge these crews for the summer season. These weirs were also difficult to maintain.

W.F. Thompson with the Fisheries Research Institute of the University of Washington (FRI) initially proposed making visual counts of migrating salmon from observation towers (Thompson 1962). The initial experiment to count sockeye salmon was conducted on the Wood River in 1953 and again in 1954. In 1955, while continuing the Wood River project, a counting tower was set up on the Kvichak River that continued for 5 years (Becker 1962).

Studies on the Egegik River were conducted in 1956 and 1957 by the U.S.F.W.S (Rietze, 1957, Spangler and Rietze, 1958) to compare the counts obtained by counting towers with those obtained from the weir. During the period of heaviest migration, four gates were opened in the weir. Counting occurred at each gate for 20 minutes out of each hour. Counts were then converted to hourly estimates of fish passing through the weir. In comparison, four towers were employed to observe migration of sockeye salmon, two above the weir and two below the weir. Towers located below the weir were improperly placed to enumerate the escapement because of large numbers of fish moving downstream. Towers located above the weir, however, provided an estimate of the sockeye escapement that agreed with the weir estimate. In 1956, an estimated 984,908 fish passed the counting towers as compared with 1,063,877 salmon counted through the weir during the sampling period. This represents a –7.4% relative error in the tower estimate with respect to the weir estimate. In 1957 an estimated 712,124 salmon passed the counting towers while 631,001 fish were estimated to have passed the weir during the sampling period. This represents a +12.9% relative error in the tower estimate with respect to the weir estimate. Because this error was small, weirs were discontinued in Bristol Bay. In 1957, all major streams in Bristol Bay were monitored with counting towers.

Currently in the Bristol Bay area there are eight sockeye salmon counting towers in operation; four on the eastside and four on the westside (Figure 1). Tower projects on the eastside of Bristol Bay are located on the Kvichak, Naknek, Egegik and Ugashik Rivers. The Kvichak River towers (Figure 2) are located on the mainstem of the river, approximately one quarter mile downstream of Lake Iliamna's outlet. The Naknek River tower (Figure 3) is located near the Naknek River "rapids", three miles downstream of the outlet of Naknek Lake. The Egegik River towers (Figure 4) are situated between the outlet of Becharof Lake and Egegik Lagoon. The Ugashik River towers (Figure 5) are located between the Lower Ugashik Lake and Ugashik Lagoon. The four tower projects on the westside of Bristol Bay are located on the Wood, Nuyakuk, Igushik, and Togiak Rivers. Wood River towers (Figure 6) are located downstream of the outlet of Lake Aleknagik. Nuyakuk River towers (Figure 7) are approximately two miles upstream of the confluence of the Nuyakuk and Nushagak Rivers. Igushik River towers (Figure 8) are located near the outlet of Amanka Lake. Togiak River towers (Figure 9) are situated near the outlet of Togiak Lake.

The Kvichak River Tower is the oldest project on the eastside, operating since 1955. The Wood River Tower is the oldest continuous westside tower project, operating since 1956. Other tower projects have operated occasionally. The Branch River Tower only operated from 1957 until 1976. A review of the field notes from the Branch River indicates that most days had incomplete counts due to poor visibility. The Snake River Tower Project was converted to a weir for an enhancement project in 1974. Nuyakuk River Tower Project was operated from 1959 to 1988 and was terminated when funding ceased. ADF&G and FRI initiated a joint project to resume counting on the Nuyakuk River in 1995. It has operated continuously since that time but was fully funded by the Department in 1999. The Nuyakuk project has an uncertain future at this time.

The following is a listing of all sockeye salmon counting towers and the years of operation.

RIVER SYSTEM	YEARS OF OPERATION	STATUS
EGEGIK	1957-1999	CURRENT
KVICHAK	1955-1999	CURRENT
NAKNEK	1958-1999	CURRENT
UGASHIK	1957-1999	CURRENT
WOOD	1956-1999	CURRENT
IGUSHIK	1958-1999	CURRENT
NUYAKUK	1959-1988 and 1995-1999	Tentative funding
TOGIAK	1960-1999	CURRENT
BRANCH	1957-1976	NONOPERATIONAL
SNAKE	1960-1973	NONOPERATIONAL

Historical tower counts by river system, year and day can be found in Appendix A.1-A.8. Wherever possible, information from archived files is included. Appendix C contains historic informational reports that are no longer in print and difficult to obtain. Tower counts have been presented in Annual Management Reports (AMR) from 1960 to 1999. These reports occasionally noted seasonal anomalies. For example, in the 1971 AMR, spring arrived late in Bristol Bay and this also caused a slight delay in sockeye salmon migration. Most AMR's do not, however, have supporting text to explain seasonal anomalies or sockeye escapement trends, and seasonal information regarding sockeye migration is not noted in this report.

A historical comparison of sockeye salmon escapement counts with annual escapement ranges and point goals for each river can be found in Tables 1-7. Annual tower counts for the eight major sockeye counting tower projects in Bristol Bay are presented in Table 8. Escapement data for 1999 is provided in Tables 9-16.

MATERIALS AND METHODS

Site Selection

The locations of sockeye salmon counting towers have changed very little over time. All tower sites are located near the outlet of rearing lakes, except for the Nuyakuk tower, which is located several miles upstream of the confluence of the Nuyakuk River and the Nushagak River. The Egegik, and Ugashik tower sites are located at the original weir sites (Rietze 1957). The Naknek tower site moved from the original weir site after a few years of operation to it's present location.

Ideally, a counting tower site is located where the water velocity encourages fish to travel close to the banks and where "crossing over" of fish from one river bank to the other is minimal. Another important criteria for a counting site is clear water. Water will be clear if the bank is stable, the substrate hard, and the site is sheltered from high winds. Counting towers do not provide useful data if estimated on rivers containing significant quantities of glacial material.

Site Description

Following are descriptions of Bristol Bay towers. Graphs representing westside tower sites with bottom profiles and fish passage range can be found in figures 10 through 13. Data collection will continue until it has been completed for all towers in the bay.

Wood River Tower

The tower site is located about 400 meters downstream of Lake Aleknagik on the Wood River. A cabin, bunkhouse, net shed, and shop are found on the right bank (RB) of the lagoon at the end of the road in the Atsat Subdivision off Lake Road. A wall tent is located on the left bank (LB) near the Kohler residence property line. The tower is placed 150 feet downstream of the tent at about three feet from shore. The right bank(RB) tower is placed about 300 feet upstream of the left bank(LB) tower site about 4 feet from shore. Sockeye travel on the LB between six and forty feet from shore with the highest passage within the twelve to twenty-five feet range. On the RB sockeye swim within one-half foot to fifty feet of the shore. Most fish on the RB pass at twenty to twenty-five feet. The tidal fluctuation of several feet at this site moves the fish passage. High water levels and large numbers of fish tend to bring the fish closer to shore. When salmon numbers drop or become sporadic and water is low, fish tend to migrate further away from shore.

Igushik Tower

The tower site is located at the mouth of Amanka Lake on the Igushik River. A cabin, shed, and a wall tent are situated about 100 yards downstream of the mouth on the LB. The LB tower is located 120 feet downstream of the cabin directly on the shore. The RB tower is located directly across the river from the cabin site about 3 feet from the shoreline. Sockeye salmon on the LB travel between thirteen and forty-five feet from shore with most passage of fish twenty to thirty feet from shore. On the RB fish migration was between twenty-five to fifty-five feet with the highest percentage of passage within the thirty to thirty-five foot corridor. This system is very shallow when compared to others in Bristol Bay and fish travel at greater distances from shore, sometimes even in the middle. Because of good water clarity and shallow river depth, spotting sockeye is not difficult.

Nuyakuk Tower

The tower site is located approximately 8 miles upstream of the Nuyakuk and Nushagak Rivers, near a small lagoon and slough. A cabin and shed are located on the LB on a river bend near the lagoon. The LB tower is placed on the bank about 300 feet downstream of the cabin. The RB tower is located directly across from the cabin on the shoreline. Sockeye salmon on the LB travel from five to thirty feet from shore with the highest percentage of fish in the area from fifteen to twenty feet from shore. On the RB sockeye traveled from five to twenty-five feet with the highest percentage at ten to fifteen feet. Nuyakuk tower site has a greater depth than all the other sites. The shoreline drops abruptly which causes the fish to swim close to shore.

Togiak Tower

The tower site is located about a mile downstream from the mouth of Togiak Lake. Two cabins and a shed are approximately 150 yards upstream of the towers. The RB tower is on a bluff with a wall tent directly behind the tower. The LB tower is positioned directly across from the RB tower and is placed approximately twenty feet from shore. On the LB sockeye salmon migrate between thirty and sixty-five feet from shore with the highest percentage of fish within forty to forty-five feet from shore. On the RB fish migrate from ten to fifty feet from shore with the highest percentage migrating from twenty to twenty-five feet. In the 1999 season the LB tower was moved thirty-five feet from shore in order to adequately count fish. Since water level had dropped remarkedly, the school of sockeye were generally spreadout at large distance from shore.

Kvichak Tower

On the LB sockeye salmon migrate from ten to thirty feet from shore. Most passage is close to th bank due to higher water velocity further away from the bank. On the RB sockeye migrate from twelve to thirty feet from shore.

Naknek Tower

On the LB fish migrate from twenty to forty-five feet from shore. Fish migration on the RB ranges from fifteen to thirty feet from shore. The higher velocity on the RB had a tendency to move the fish closer to shore but the LB migration was more uniform and spread out over a wider area.

Egegik Tower

The LB sockeye migration occurs in an area from twenty to forty feet from shore. Right Bank (RB) passage of sockeye occurs from fifteen to thirty-five from shore.

Ugashik Tower

The LB migration occurs in an area from ten to twenty-five feet from shore. The RB sockeye migration is also from ten to twenty-five feet from shore. Water velocity was not attained during the duration of the tower project but the fast water beyond twenty-five feet on either side tends to push fish towards the shoreline. The migration on the LB is through a portion of back water so that fish are able to swim at various depths and become stacked when in large concentrations. The LB deep channel allows fish to swim deep and makes them difficult to count.

Equipment

The two counting towers reach a height of twenty feet at most sites. Each tower is made of aluminum scaffolding and supports a platform at the top where the observer stands or sits while counting. Some towers have tarpaulins for shelter.

Different kinds of artificial substrate are placed on the bottom of the river to make fish more visible. The substrate could be canvas that has been painted white, white boards wired together, or a metal grating that has been painted white. Substrates may be held in place by sandbags or large rocks or they may be staked on the bottom.

During the night, lights are used to illuminate the counting areas. Initially red and blue colored lights were used to increase visibility at night. However, colored lights did not work well. They were not bright enough to provide adequate light for observers and caused fish to move offshore during migration. Currently, standard white automobile headlights are used. These lights are placed to enhance night visibility. The offshore illumination guides fish closer to the substrate. The lights are mounted in boxes at the top of each tower and are powered by 12 volt batteries. The batteries are charged daily with solar panels or gasoline-powered generators.

Each tower site also has equipment to assist with visibility during windy weather. A triangular shaped apparatus made from wood that floats on the water, is called a "riffle damper", is placed in the water just upstream of the tower to smooth out the river surface and improve visibility. At the Ugashik counting towers the wind is often too strong for a riffle damper to work effectively and alternative sites have been established for counting on stormy days. Alternative sites are accessible on foot and sites use platform stepladders that are tethered with steel cables for stability in high wind.

Some sites have "fish deflectors" that cause fish to move closer to the bank and stay within the tower observer's vision. Fish deflectors can be made of bright buoys, light colored flagging or a white board on the bottom.

Each camp has two aluminum skiffs and outboard motors. The crewmembers use these skiffs to travel from their living site to the counting site and also to different areas of the river to catch and sample fish for length, age-class and sex data.

Age and sex information on the migrating sockeye salmon are collected using a seine. Crews use either a beach or trip seine to gather fish. Beach seines are held in the current while fish collect in them and then are brought to the beach. Trip seines are held against the current until enough fish trip the net, which then surrounds and holds the school. A dipnet is then used to move the seined fish into a partially submerged holding pen made of wood or PVC pipe. The holding pens may hold 50 to 150 fish.

To communicate with the King Salmon or Dillingham offices, each tower camp is provided with a single sideband radio. Management biologists are provided with fish passage rates, sampling information and weather conditions. In recent years, communication at several camps has been improved with the use of cellular phones. These phones have allowed crews to communicate more freely with field offices and have added an extra measure of safety in the event of an emergency.

Housing

Each camp has a main cabin for the crew. Most sites also have a tent that is located next to the tower site that houses the radio and sampling equipment. Some camps have a separate structure for sleeping quarters. Each camp has an outhouse and a sauna. Some sites have a building to store supplies over the winter.

Personnel

During the early years, tower crews consisted of two-to-four crewmembers. All tower projects in Bristol Bay now employ three crew members. Field crews are assisted by a field camp coordinator and a project biologist. The field camp coordinator travels to each camp several times during the short season and provides boat safety instruction and training for new crew members in species identification fish species and counting techniques. The coordinator is usually present during periods of high fish passage to provide quality control and sampling assistance.

Operations

Each counting tower project is assigned an operating period over which it is assumed it will count the majority of the sockeye salmon migrating through the drainage. Beginning dates are coordinated to allow the crews to arrive at the beginning of the normal migration. Tower project ending dates are finalized inseason. Typically when tower counts drop to less than one percent of the total escapement, for three consecutive days; the tower counting project is terminated for the season.

Field crews are sent out from Dillingham and King Salmon by chartered plane or if the towers are close to town, they travel by skiff to the tower site. Crews usually spend one day setting up the towers and are able to begin counting fish from the tower by the second day. As soon as the towers have been set up, each person works an eight-hour shift so that an estimate of fish passage can be made 24 hours a day.

The procedure for counting is as follows:

1) A fish count is made at the top of the hour for ten minutes from one tower;
2) The person records the number, leaves the tower and uses a skiff to move to the opposite side of the river;
3) At twenty minutes after the hour another fish count is made for ten minutes;
4) Each 10-minute count from each tower is expanded by a factor of six and then totaled to yield an hourly passage estimate for the whole river.

Audible timers are used to delineate counting intervals. Counts are reported by radio or telephone to the area office several times daily.

As the sockeye salmon migration progresses, samples to determine age, sex, and length are collected using a beach or trip seine. Sockeye salmon lengths are measured with calipers from the mid-eye to the fork in the tail to the nearest millimeter. Sex is determined by external inspection. A scale is removed from each fish and affixed to a gum card for future age determination.

Samples are collected in a systematic manner in order to have a statistically valid representation of the spawning population. Sample size goals for sockeye are set at 500 fish per species per stratum. Togiak tower, Igushik tower and Nuyakuk tower collect 2 stratum and the remainder of the tower projects collect 3 stratum. Sample size goals for each tower project may be adjusted annually to account for high numbers of unreadable scales encountered the previous year. These goals were selected to ensure that a sufficient sample would be collected, such that each major age group in each stratum would be estimated within 5% of its true value with 90% probability.

RESULTS

Tower Counts

The 1999 Bristol Bay Tower data by river system and day are listed in Tables 9-16. Historical tower data for currently operating towers for all years by river system and day are in Appendixes A.1-A.8. These appendix tables list sockeye salmon counts for each of the eight major towers that operated since 1960. Historic tower data of other species are listed in Tables 17-20. Appendix B contains tower data for tower projects that are no longer operating. Historical tower counts by river system by year are given in Table 8.

Diagnostics

Hourly Counts

Daily estimates from counting towers have been published in annual reports of the USFWS and ADF&G. The USFWS evaluated tower counts when projects were operated simultaneously with weirs (Spangler and Reitze 1957). When the first towers began operation, counts were made at five, ten and twenty minute periods. After evaluation of these different strategies, towers used 15 minute counting periods and then changed to one 10-minute counting period (Seibel, 1967). Ten-minute hourly counts have been used since, and have been periodically checked for accuracy. In 1965 and 1966 tower data was collected from six rivers in Bristol Bay, one in Norton Sound and one in Prince William Sound. This study compared whole hour counts to 10-minute counts that were expanded by six to represent an hourly count. This report concluded that 10 minute counts provided an acceptable level of accuracy (Seibel,1967).

Comparison Counts

In the mid-fifties, it became necessary to find an alternative counting method to weirs. Counting towers were operated simultaneously with the weirs so that the two methods could be compared. The Bureau of Commercial Fisheries, USFWS, compared tower counts with the weir count at the Egegik River weir from July 12 to July 30, 1956 (Reitze 1957). The tower count of 984,908 was only 7.4 percent lower than the weir count of 1,063,877. Most of the difference occurred on July 16 and 17 when the fish switched to the opposite side of the river where there was no counting tower. If these two days were eliminated from the compared counts, the tower count would have been 857,390, only 1.1 percent higher than the weir count of 847,805 fish. These tower counts were made using two 15-minute counting periods each hour and produced 95 percent confidence limits for percent mean relative error of (+ or –) 3.90 percent(tower vs weir). Counts obtained from using one ten-minute period each hour produced 95 percent confidence limits of (+ or –) 6.08 percent. Data gathered by F.R.I. at the Kvichak River in 1959 (Becker, 1962) supported the conclusions of Reitze (1957(in that ten minute counts taken systematically each hour from each tower were highly efficient.

ADF&G continues to use 10-minute counts. Work documented by Seibel (1967) indicates 95 percent confidence limits of –7.1 percent to 8.9 percent for counts obtained by 10-minute hourly counts. Seibel (1967) also states, "In general, the degree of accuracy of escapement estimates obtained through the use of counting towers is comparable with the accuracy of other biological data collected and used to describe the population dynamics of salmon stocks."

In 1966, and periodically until 1972, the Wood River counting towers were used to test the accuracy of the Bendix Corporation sonar salmon counters (ADF&G 1964). During the 1967 tests, the difference between the two methods was only 1.2 percent.

Variability among counting personnel has been a concern and considered a possible source of error (ADF&G 1964). In 1971 counts were made by each of the three crew members at the Wood River Tower. A total of 18, 10-minute counts were made with each crew member: 6 during good daylight conditions, 6 at night and 6 during dawn or dusk hours.

The percentage errors between the three counters and the experienced counter were:

Crew member 1	+1.3
Crew member 2	+1.2
Crew member 3	-1.8
Combined total	+0.4

The combined total percent error for all counters was +0.4 or 117 fish for a count of 29,000 fish. In general, the lower the actual counts in a 10-minute interval, the lower the percent errors between counters. The percent error for 33 counts of 0-200 fish was only –0.09 percent, while for ten counts of 800-2,500 fish the variation was +1.8 percent.

Department biologists periodically check the accuracy of tower employee counts and ensure that accuracy and consistency are maintained. The tower camp coordinator will complete hourly counts with each crew member several times during a season to ensure that each crew member is able to count in a consistent manner. Comparison counts from eastside towers for 1999 can be found in Appendix C. New crew members were checked for 24 to 48 hours during their training to ensure accuracy in counting. Crew members with several years of experience were checked for 16 to 20 hours.

Conditions for 1999 Bristol Bay Towers

Since spring arrived late, tower crews had to deal with colder than normal temperatures and several systems had high water. There were several storms, one severe enough to cause turbidity at the Ugashik tower for a brief period. During 1999 fish behavior at the Egegik and Ugashik towers was somewhat unusual. Cold lake water caused sockeye salmon to hold in the lower half of Egegik and Ugashik Lagoons and in the Egegik and Ugashik Rivers. After fish swam past the tower and entered the lake a portion of them returned to the tower area and mixed with fish that were moving up from the lagoon. This occurred with greater frequency early in the season when the lake water was the coldest.

During 1999 the water velocity and river width were collected from each site. Water velocity was taken with a Model 622 Teledyne Gurley meter.

Tower	Velocity and River Width
Wood River	July 7 @ 2.59 ft./sec and river width of 320 ft.
Igushik River	July 7 @4.01ft/sec and river width of 170 ft.
Nuyakuk River	July 11 @ 2.49 ft./sec and river width of 370 ft.
Togiak River	July 16 @ 1.95 ft./sec and river width of 190 ft.
Kvichak River	July 16 @LB 2.4 ft/sec and RB 1.7 ft/sec
Naknek River	June 27 @RB 4.4 ft/sec
Egegik River	River width is 150 meters. Velocity not available
Ugashik River	No information available

The 1999 Bristol Bay counting tower data is presented in Tables 9-16. Escapement at all tower projects ranged from 46 percent below to 122 percent over the point goals. The 1999 inshore sockeye salmon run of 39.5 million fish was 14.6 million fish more than the forecast of 24.9 million. Sockeye runs were greater than anticipated in all drainages. The 1999 inshore sockeye salmon run arrived early inshore but migrated into the systems later than usual. It appeared that inshore water temperatures were cold so fish held in warmer waters. For example, in Egegik River the fish piled up in the lagoon for several tides before moving past the tower. Escapement data from the tower projects was relied on heavily inseason in order to balance escapement with harvestable surplus. Tables 1-7 present escapement goal ranges and escapements for each tower project.

The Bristol Bay database Mariner was again utilized inseason. This database contains inseason escapement numbers from towers as well as commercial catch information. This was the third season that the tower data was entered inseason on Mariner and became available to the public on the Bristol Bay "daily" information page. This same information is also published on the Department of Fish and Game Bristol Bay homepage on the Internet.

(www.cf.adfg.state.ak.us./region2/finfish/salmon/bbayhome.htm.)

During 1999 archived data from four towers from the years 1980-1999 were checked for math errors and entered into a new database. Data changes are reflected in the historical tower data for the following towers: Kvichak tower, Egegik tower, Ugashik tower and Igushik tower.

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Tables 1-20

Annual sockeye tower counts and

Escapement goals in Bristol Bay

Table 1. Annual sockeye salmon tower counts and escapement goals, Egegik River, 1957-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1957			391,207
1958			246,354
1959			1,052,819
1960			1,798,759
1961			701,538
1962		350,000	1,027,482
1963		850,000	997,602
1964		850,000	849,576
1965		1,000,000	1,444,608
1966		1,000,000	804,246
1967		1,000,000	636,864
1968		1,000,000	338,654
1969		400,000	1,015,554
1970		700,000	919,734
1971		1,000,000	634,014
1972		600,000	546,402
1973	400-600,000	600,000	328,842
1974		500,000	1,275,630
1975		600,000	1,173,840
1976		600,000	509,160
1977		600,000	692,514
1978		600,000	895,698
1979		600,000	1,032,042
1980		600,000	1,060,920
1981		600,000	694,680
1982		600,000	1,034,628
1983		600,000	792,282
1984	800-1,200,000	1,000,000	1,165,320
1985	800-1,200,000	1,000,000	1,095,204
1986	800-1,200,000	1,000,000	1,151,320
1987	800-1,200,000	1,000,000	1,272,978
1988	800-1,200,000	1,000,000	1,599,096
1989	800-1,200,000	1,000,000	1,610,916
1990	800-1,200,000	1,000,000	2,191,362
1991	800-1,200,000	1,000,000	2,786,880
1992	800-1,200,000	1,000,000	1,945,332
1993	800-1,200,000	1,000,000	1,516,980
1994	800-1,200,000	1,000,000	1,897,932
1995	800-1,400,000	1,000,000	1,281,678
1996	800-1,400,000	1,000,000	1,075,596
1997	800-1,400,000	1,000,000	1,103,964
1998	800-1,400,000	1,100,000	1,110,882
1999	800-1,400,000	1,100,000	1,727,772

Table 2. Annual sockeye salmon tower counts and escapement goals, Igushik River, 1958-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1958			107,478
1959			643,808
1960			495,087
1961			294,252
1962		60,000	15,660
1963		400,000	92,184
1964		250,000	128,532
1965		250,000	180,840
1966		200,000	206,360
1967		153,000	281,772
1968		150,000	194,508
1969		200,000	512,328
1970		200,000	370,920
1971		150,000	210,960
1972		150,000	60,018
1973		150,000	59,508
1974		150,000	358,752
1975		150,000	241,086
1976		150,000	186,120
1977		150,000	95,970
1978		150,000	536,154
1979		150,000	859,560
1980		150,000	1,987,530
1981		150,000	591,144
1982		150,000	423,768
1983		200,000	180,420
1984	150,000-250,000	200,000	184,872
1985	150,000-250,000	200,000	212,418
1986	150,000-250,000	200,000	308,820
1987	140,000-250,000	200,000	169,236
1988	140,000-250,000	200,000	170,406
1989	150,000-250,000	200,000	461,610
1990	150,000-250,000	200,000	365,796
1991	150,000-250,000	200,000	756,126
1992	150,000-250,000	200,000	304,920
1993	150,000-250,000	200,000	405,564
1994	150,000-250,000	200,000	445,920
1995	150,000-250,000	200,000	473,382
1996	150,000-250,000	200,000	400,746
1997	150,000-250,000	200,000	127,704
1998	150,000-250,000	200,000	215,904
1999	150,000-250,000	200,000	445,536

Table 3. Annual sockeye salmon tower counts and escapement goals, Kvichak River, 1955-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1955			250,546
1956			9,443,318
1957			2,964,755
1958			534,785
1959			673,811
1960			14,602,360
1961	3,000,000-4,500,000	10,000,000	3,705,729
1962	2,500,000-3,500,000	2,500,000	2,580,884
1963	750,000-1,500,000	750,000	338,570
1964	4,500,000-8,000,000	5,000,000	956,616
1965	6,000,000-10,000,000	8,000,000	24,320,580
1966	5,000,000-7,000,000	6,000,000	3,756,184
1967	3,000,000-5,000,000	3,500,000	3,215,950
1968	500,000-3,500,000	874,000	2,556,432
1969	5,000,000-7,000,000	6,000,000	8,394,174
1970	15,000,000-23,000,000	19,000,000	13,916,346
1971		2,500,000	2,381,266
1972		2,000,000	1,009,962
1973		2,000,000	226,554
1974		6,000,000	4,433,844
1975		14,000,000	13,140,354
1976		2,000,000	1,965,282
1977		2,000,000	1,341,102
1978		2,000,000	4,149,126
1979		6,000,000	11,216,628
1980		14,000,000	22,505,268
1981		2,000,000	1,754,352
1982		2,000,000	1,134,420
1983		2,000,000	3,569,982
1984	8,000,000-12,000,000	10,000,000	10,490,646
1985	8,000,000-12,000,000	10,000,000	7,210,914
1986	4,000,000-8,000,000	5,000,000	1,179,502
1987	4,000,000-8,000,000	5,000,000	6,065,886
1988	4,000,000-8,000,000	5,000,000	4,065,216
1989	6,000,000-10,000,000	8,000,000	8,319,552
1990	6,000,000-10,000,000	6,000,000	6,970,020
1991	4,000,000-8,000,000	4,000,000	4,222,788
1992	4,000,000-8,000,000	6,000,000	4,725,864
1993	4,000,000-8,000,000	5,000,000	4,025,166
1994	6,000,000-10,000,000	8,000,000	8,355,936
1995	6,000,000-10,000,000	10,000,000	10,038,720
1996	6,000,000-10,000,000	4,000,000	1,450,578
1997	6,000,000-10,000,000	4,000,000	1,503,732
1998	2,000,000-10,000,000	50% of projection	2,296,074
1999	800,000-1,400,000	50% of projection	6,196,914

Table 4. Annual sockeye salmon tower counts and escapement goals, Naknek River, 1958-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1958			278,118
1959			2,231,807
1960			828,381
1961			351,078
1962			723,066
1963		750,000	905,358
1964		850,000	1,349,604
1965		800,000	717,798
1966		800,000	1,016,445
1967		1,000,000	755,640
1968		1,000,000	1,023,222
1969		1,000,000	1,331,202
1970		1,000,000	732,502
1971		900,000	935,754
1972		800,000	586,518
1973		800,000	356,676
1974		800,000	1,241,058
1975		800,000	2,026,686
1976		800,000	1,320,750
1977		800,000	1,085,856
1978		800,000	813,378
1979		800,000	925,362
1980		800,000	2,644,686
1981		800,000	1,796,220
1982		800,000	1,155,552
1983		800,000	888,078
1984	800,000-1,400,000	1,000,000	1,242,474
1985	800,000-1,400,000	1,000,000	1,849,988
1986	800,000-1,400,000	1,000,000	1,977,645
1987	800,000-1,400,000	1,000,000	1,061,806
1988	800,000-1,400,000	1,000,000	1,037,244
1989	800,000-1,400,000	1,000,000	1,161,984
1990	800,000-1,400,000	1,000,000	2,092,578
1991	800,000-1,400,000	1,000,000	3,578,548
1992	800,000-1,400,000	1,000,000	1,606,650
1993	800,000-1,400,000	1,000,000	1,535,658
1994	800,000-1,400,000	1,000,000	990,810
1995	800,000-1,400,000	1,000,000	1,111,140
1996	800,000-1,400,000	1,000,000	1,078,098
1997	800,000-1,400,000	1,000,000	1,025,664
1998	800,000-1,400,000	1,100,000	1,202,172
1999	800,000-1,400,000	1,100,000	1,625,364

Table 5. Annual sockeye salmon tower counts and escapement goals, Togiak River, 1960-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1960			162,810
1961			94,452
1962		80,000	47,352
1963		100,000	102,396
1964		100,000	95,574
1965		150,000	88,462
1966		120,000	91,098
1967		90,000	69,330
1968		110,000	42,918
1969		100,000	109,266
1970		100,000	192,096
1971		115,000	190,842
1972		70,000	74,070
1973	60,000-100,000	80,000	95,730
1974		100,000	82,992
1975		100,000	160,962
1976		100,000	158,190
1977		100,000	133,734
1978		100,000	273,576
1979		100,000	171,138
1980		100,000	461,850
1981		100,000	208,080
1982		100,000	244,734
1983		100,000	191,520
1984	140,000-250,000	150,000	95,448
1985	140,000-250,000	150,000	136,542
1986	140,000-250,000	150,000	168,384
1987	140,000-250,000	150,000	249,676
1988	140,000-250,000	150,000	276,612
1989	140,000-250,000	150,000	84,480
1990	140,000-250,000	150,000	141,977
1991	140,000-250,000	150,000	254,683
1992	140,000-250,000	150,000	199,134
1993	140,000-250,000	150,000	177,185
1994	140,000-250,000	150,000	154,752
1995	140,000-250,000	150,000	185,718
1996	140,000-250,000	150,000	156,954
1997	140,000-250,000	150,000	131,682
1998	140,000-250,000	150,000	153,576
1999	140,000-250,000	150,000	155,898

Table 6. Annual sockeye salmon tower counts and escapement goals, Ugashik River, 1957-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1957			214,802
1958			279,540
1959			219,223
1960			2,294,200
1961	500,000-1,000,000 a	Unknown	348,658
1962		750,000	255,426
1963		650,000	388,254
1964		600,000	472,770
1965		800,000	991,056
1966		850,000	702,834
1967		850,000	238,830
1968		750,000	70,542
1969		400,000	160,380
1970		700,000	726,192
1971		500,000	500,370
1972		450,000	79,428
1973	350,000-500,000	450,000	38,988
1974		500,000	61,854
1975		500,000	429,336
1976		500,000	340,218
1977		500,000	201,486
1978		500,000	70,434
1979		500,000	1,700,904
1980		500,000	3,321,354
1981		500,000	1,326,762
1982		500,000	1,157,526
1983		500,000	1,000,608
1984	500,000-900,000	700,000	1,241,418
1985	500,000-900,000	700,000	998,232
1986	500,000-900,000	700,000	1,001,492
1987	500,000-900,000	700,000	668,964
1988	500,000-900,000	700,000	642,972
1989	500,000-900,000	700,000	1,681,296
1990	500,000-900,000	700,000	730,038
1991	500,000-900,000	700,000	2,457,306
1992	500,000-900,000	700,000	2,173,692
1993	500,000-900,000	700,000	1,389,534
1994	500,000-900,000	700,000	1,080,858
1995	500,000-1,200,000	700,000	1,304,058
1996	500,000-1,200,000	700,000	667,518
1997	500,000-1,200,000	700,000	618,396
1998	500,000-1,200,000	850,000	890,508
1999	500,000-1,200,000	850,000	1,651,572

[a] includes Mother Goose System

Table 7. Annual sockeye salmon tower counts and escapement goals, Wood River, 1956-1999.

YEAR	Escapement Goal Range	Midpoint Objective	Tower Escapement
1956			773,101
1957			288,727
1958			959,630
1959			2,209,209
1960			1,015,767
1961	600,000-700,000	Unknown	460,737
1962		450,000	873,888
1963		1,200,000	721,350
1964		900,000	1,076,088
1965		500,000	675,156
1966		900,000	1,208,658
1967		1,100,000	515,598
1968		1,000,000	649,344
1969		750,000	604,338
1970		1,000,000	1,161,918
1971		750,000	851,202
1972		750,000	430,602
1973		700,000	330,438
1974		800,000	1,708,704
1975		800,000	1,270,116
1976		800,000	816,996
1977		800,000	561,828
1978		800,000	2,266,020
1979		800,000	1,705,602
1980		800,000	2,968,620
1981		800,000	1,231,920
1982		800,000	976,470
1983		1,000,000	1,360,350
1984	700,000-1,200,000	1,000,000	1,002,792
1985	700,000-1,200,000	1,000,000	939,000
1986	700,000-1,200,000	1,000,000	818,652
1987	700,000-1,200,000	1,000,000	1,337,172
1988	700,000-1,200,000	1,000,000	866,778
1989	700,000-1,200,000	1,000,000	1,186,410
1990	700,000-1,200,000	1,000,000	1,069,368
1991	700,000-1,200,000	1,000,000	1,159,578
1992	700,000-1,200,000	1,000,000	1,284,870
1993	700,000-1,200,000	1,000,000	1,176,054
1994	700,000-1,200,000	1,000,000	1,471,890
1995	700,000-1,200,000	1,000,000	1,482,162
1996	700,000-1,200,000	1,000,000	1,649,598
1997	700,000-1,200,000	1,000,000	1,512,396
1998	700,000-1,200,000	1,000,000	1,755,768
1999	700,000-1,200,000	1,000,000	1,512,426

Table 8. Annual sockeye salmon tower counts, 1955-1999.

YEAR	Egegik Tower Escapement	Naknek Tower Escapement	Kvichak Tower Escapement	Ugashik Tower Escapement
1955			250,546	
1956			9,443,318	
1957	391,207		2,964,755	214,802
1958	246,354	278,118	534,785	279,540
1959	1,052,819	2,231,807	673,811	219,223
1960	1,798,759	828,381	14,602,360	2,294,200
1961	701,538	351,078	3,705,729	348,658
1962	1,027,482	723,066	2,580,884	255,426
1963	997,602	905,358	338,570	388,254
1964	849,576	1,349,604	956,616	472,770
1965	1,444,608	717,798	24,320,580	991,056
1966	804,246	1,016,445	3,756,184	702,834
1967	636,864	755,640	3,215,950	238,830
1968	338,654	1,023,222	2,556,432	70,542
1969	1,015,554	1,331,202	8,394,174	160,380
1970	919,734	732,502	13,916,346	726,192
1971	634,014	935,754	2,381,266	500,370
1972	546,402	586,518	1,009,962	79,428
1973	328,842	356,676	226,554	38,988
1974	1,275,630	1,241,058	4,433,844	61,854
1975	1,173,840	2,026,686	13,140,354	429,336
1976	509,160	1,320,750	1,965,282	340,218
1977	692,514	1,085,856	1,341,102	201,486
1978	895,698	813,378	4,149,126	70,434
1979	1,032,042	925,362	11,216,628	1,700,904
1980	1,060,860	2,644,686	22,505,268	3,321,354
1981	694,680	1,796,220	1,754,352	1,326,762
1982	1,034,628	1,155,552	1,134,420	1,157,526
1983	792,282	888,078	3,569,982	1,000,608
1984	1,165,320	1,242,474	10,490,646	1,241,418
1985	1,095,192	1,849,988	7,210,914	998,232
1986	1,151,320	1,977,645	1,179,502	1,001,492
1987	1,272,978	1,061,806	6,065,886	668,964
1988	1,612,680	1,037,244	4,065,216	642,972
1989	1,610,916	1,161,984	8,319,552	1,681,296
1990	2,191,362	2,092,578	6,970,020	730,038
1991	2,786,880	3,578,548	4,222,746	2,457,306
1992	1,945,332	1,606,650	4,725,864	2,173,692
1993	1,516,980	1,535,658	4,025,166	1,389,534
1994	1,897,932	990,810	8,337,840	1,080,858
1995	1,220,142	1,111,140	10,038,720	1,304,058
1996	1,075,596	1,078,098	1,450,578	667,518
1997	1,103,964	1,025,664	1,503,732	618,396
1998	1,110,888	1,202,172	2,296,074	890,508
1999	1,727,772	1,625,364	6,196,914	1,651,572

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Table 8. Annual sockeye salmon tower counts, 1955-1999.

YEAR	Wood Tower Escapement	Nuyakuk River Escapement	Igushik Tower Escapement	Togiak Tower Escapement
1955				
1956	773,101			
1957	288,727			
1958	959,630		107,478	
1959	2,209,209	48,861	643,808	
1960	1,015,767	145,500	495,087	162,810
1961	460,737	79,788	294,252	94,452
1962	873,888	37,890	15,660	47,070
1963	721,350	166,608	92,184	102,276
1964	1,076,088	103,224	128,532	95,574
1965	675,156	203,070	180,840	88,462
1966	1,208,658	161,010	206,360	90,942
1967	515,598	20,250	281,772	63,000
1968	649,344	96,642	194,508	35,256
1969	604,338	69,828	512,328	106,122
1970	1,161,918	364,648	370,920	172,914
1971	851,202	224,352	210,960	190,830
1972	430,602	28,596	60,018	74,058
1973	330,438	110,016	59,508	95,526
1974	1,708,704	154,614	358,752	68,040
1975	1,270,116	669,918	241,086	160,962
1976	816,996	425,220	186,120	158,160
1977	561,828	232,554	95,970	125,868
1978	2,266,020	576,666	536,154	207,204
1979	1,705,602	360,120	859,560	145,626
1980	2,968,620	3,026,568	1,987,530	410,058
1981	1,231,920	834,204	591,144	201,558
1982	976,470	537,864	423,768	236,322
1983	1,360,350	318,606	180,438	165,918
1984	1,002,792	472,596	184,872	86,340
1985	939,000	429,162	212,454	136,476
1986	818,652	821,898	307,728	167,694
1987	1,337,172	69,762	169,236	247,756
1988	866,778	319,992	170,454	210,270
1989	1,186,410	not operated	461,610	81,612
1990	1,069,368	not operated	365,802	137,321
1991	1,159,578	not operated	756,126	235,027
1992	1,284,870	not operated	304,920	191,358
1993	1,176,054	not operated	405,564	143,490
1994	1,471,890	not operated	445,920	154,560
1995	1,482,162	69,702	473,382	172,668
1996	1,649,598	250,692	400,674	149,172
1997	1,512,396	272,982	127,704	130,638
1998	1,755,768	146,250	215,904	153,366
1999	1,512,426	81,006	445,536	155,898

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Table 9. Daily sockeye salmon tower counts, Egegik River, 1999.[a]

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
6/19	0	0	0%	0%
6/20	0	0	0%	0%
6/21	24	24	0%	0%
6/22	24	48	0%	0%
6/23	66	114	0%	0%
6/24	30	144	0%	0%
6/25	18	162	0%	0%
6/26	78	240	0%	0%
6/27	450	690	0%	0%
6/28	60	750	0%	0%
6/29	2,970	3,720	0%	0%
6/30	5,598	9,318	1%	1%
7/1	56,400	65,718	3%	4%
7/2	61,002	126,720	4%	8%
7/3	211,962	338,682	12%	20%
7/4	98,436	437,118	6%	25%
7/5	99,642	536,760	6%	31%
7/6	173,484	710,244	10%	41%
7/7	262,872	973,116	15%	56%
7/8	163,278	1,136,394	9%	66%
7/9	194,010	1,330,404	11%	77%
7/10	141,978	1,472,382	8%	85%
7/11	90,372	1,562,754	5%	90%
7/12	85,824	1,648,578	5%	95%
7/13	23,178	1,671,756	1%	97%
7/14	16,860	1,688,616	1%	98%
7/15	19,572	1,708,188	1%	99%
7/16	7,812	1,716,000	0%	99%
7/17	11,772	1,727,772	1%	100%
Total	1,727,772			

[a] On 7/14 hour 5 on RB missed due to motor trouble; 7/15 hours1-4 RB and 2-4 LB missed due to bear problem.

Table 10. Daily sockeye salmon tower counts, Igushik River, 1999.

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
6/25	6	6	0%	0%
6/26	0	6	0%	0%
6/27	0	6	0%	0%
6/28	0	6	0%	0%
6/29	0	6	0%	0%
6/30	2,958	2,964	1%	1%
7/1	4,632	7,596	1%	2%
7/2	23,532	31,128	5%	7%
7/3	30,342	61,470	7%	14%
7/4	34,410	95,880	8%	22%
7/5	49,140	145,020	11%	33%
7/6	42,168	187,188	9%	42%
7/7	45,486	232,674	10%	52%
7/8	39,072	271,746	9%	61%
7/9	41,340	313,086	9%	70%
7/10	23,874	336,960	5%	76%
7/11	12,258	349,218	3%	78%
7/12	8,124	357,342	2%	80%
7/13	8,694	366,036	2%	82%
7/14	7,536	373,572	2%	84%
7/15	5,850	379,422	1%	85%
7/16	10,968	390,390	2%	88%
7/17	13,176	403,566	3%	91%
7/18	14,490	418,056	3%	94%
7/19	8,796	426,852	2%	96%
7/20	6,036	432,888	1%	97%
7/21	6,600	439,488	1%	99%
7/22	6,048	445,536	1%	100%
Total	445,536			

Table 11. Daily sockeye salmon tower counts, Kvichak River, 1999.

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
6/24	0	0	0%	0%
6/25	54	54	0%	0%
6/26	36	90	0%	0%
6/27	90	180	0%	0%
6/28	24	204	0%	0%
6/29	234	438	0%	0%
6/30	16,962	17,400	0%	0%
7/1	87,450	104,850	1%	2%
7/2	232,242	337,092	4%	5%
7/3	411,228	748,320	7%	12%
7/4	338,088	1,086,408	5%	18%
7/5	437,124	1,523,532	7%	25%
7/6	304,272	1,827,804	5%	29%
7/7	428,358	2,256,162	7%	36%
7/8	532,554	2,788,716	9%	45%
7/9	403,932	3,192,648	7%	52%
7/10	395,958	3,588,606	6%	58%
7/11	215,850	3,804,456	3%	61%
7/12	228,000	4,032,456	4%	65%
7/13	299,562	4,332,018	5%	70%
7/14	317,820	4,649,838	5%	75%
7/15	298,842	4,948,680	5%	80%
7/16	162,348	5,111,028	3%	82%
7/17	310,638	5,421,666	5%	87%
7/18	428,550	5,850,216	7%	94%
7/19	189,006	6,039,222	3%	97%
7/20	70,278	6,109,500	1%	99%
7/21	41,988	6,151,488	1%	99%
7/22	24,882	6,176,370	0%	99%
7/23	20,544	6,196,914	0%	100%
Total	6,196,914			

Table 12. Daily sockeye salmon tower counts, Naknek River, 1999. [a]

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
6/23	0	0	0%	0%
6/24	2,724	2,724	0%	0%
6/25	1,374	4,098	0%	0%
6/26	564	4,662	0%	0%
6/27	4,122	8,784	0%	0%
6/28	4,836	13,620	0%	0%
6/29	104,754	118,374	2%	2%
6/30	147,564	265,938	2%	4%
7/1	92,658	358,596	1%	6%
7/2	118,254	476,850	2%	8%
7/3	71,046	547,896	1%	9%
7/4	172,548	720,444	3%	12%
7/5	205,380	925,824	3%	15%
7/6	96,000	1,021,824	2%	16%
7/7	26,982	1,048,806	0%	17%
7/8	10,686	1,059,492	0%	17%
7/9	19,968	1,079,460	0%	17%
7/10	38,598	1,118,058	1%	18%
7/11	71,718	1,189,776	1%	19%
7/12	114,390	1,304,166	2%	21%
7/13	52,980	1,357,146	1%	22%
7/14	41,568	1,398,714	1%	23%
7/15	107,958	1,506,672	2%	24%
7/16	80,106	1,586,778	1%	26%
7/17	15,726	1,602,504	0%	26%
7/18	8,682	1,611,186	0%	26%
7/19	14,178	1,625,364	0%	26%
Total	1,625,364			

[a] July 7 LB hour 4 missed due to fog.

Table 13. Daily sockeye salmon tower counts, Nuyakuk River, 1999.

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
7/1				
7/2				
7/3				
7/4	60	60	0%	0%
7/5	420	480	1%	1%
7/6	4,086	4,566	5%	6%
7/7	6,654	11,220	8%	14%
7/8	15,108	26,328	19%	33%
7/9	10,242	36,570	13%	45%
7/10	10,578	47,148	13%	58%
7/11	10,134	57,282	13%	71%
7/12	7,020	64,302	9%	79%
7/13	4,560	68,862	6%	85%
7/14	948	69,810	1%	86%
7/15	1,248	71,058	2%	88%
7/16	1,464	72,522	2%	90%
7/17	1,950	74,472	2%	92%
7/18	1,560	76,032	2%	94%
7/19	786	76,818	1%	95%
7/20	456	77,274	1%	95%
7/21	462	77,736	1%	96%
7/22	840	78,576	1%	97%
7/23	882	79,458	1%	98%
7/24	594	80,052	1%	99%
7/25	390	80,442	0%	99%
7/26	564	81,006	1%	100%
Total	81,006			

Table 14. Daily sockeye salmon tower counts, Togiak River, 1999.

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
7/4	0	0	0%	0%
7/5	36	36	0%	0%
7/6	1,746	1,782	1%	1%
7/7	6,246	8,028	4%	5%
7/8	4,782	12,810	3%	8%
7/9	3,222	16,032	2%	10%
7/10	3,108	19,140	2%	12%
7/11	4,740	23,880	3%	15%
7/12	5,040	28,920	3%	19%
7/13	4,602	33,522	3%	22%
7/14	3,762	37,284	2%	24%
7/15	2,550	39,834	2%	26%
7/16	2,598	42,432	2%	27%
7/17	4,362	46,794	3%	30%
7/18	3,750	50,544	2%	32%
7/19	2,910	53,454	2%	34%
7/20	3,054	56,508	2%	36%
7/21	3,030	59,538	2%	38%
7/22	9,192	68,730	6%	44%
7/23	6,864	75,594	4%	48%
7/24	2,856	78,450	2%	50%
7/25	4,098	82,548	3%	53%
7/26	6,012	88,560	4%	57%
7/27	18,354	106,914	12%	69%
7/28	19,374	126,288	12%	81%
7/29	13,122	139,410	8%	89%
7/30	6,174	145,584	4%	93%
7/31	3,378	148,962	2%	96%
8/1	3,402	152,364	2%	98%
8/2	1,848	154,212	1%	99%
8/3	1,182	155,394	1%	99%
8/4	504	155,898	0%	100%
Total	155,898			

Table 15. Daily sockeye salmon tower counts, Ugashik River, 1999 [a]

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
7/3	0	0	0%	0%
7/4	0	0	0%	0%
7/5	0	0	0%	0%
7/6	0	0	0%	0%
7/7	6	6	0%	0%
7/8	33,180	33,186	2%	2%
7/9	203,940	237,126	12%	14%
7/10	189,654	426,780	11%	26%
7/11	183,408	610,188	11%	37%
7/12	328,740	938,928	20%	57%
7/13	354,384	1,293,312	21%	78%
7/14	78,528	1,371,840	5%	83%
7/15	88,260	1,460,100	5%	88%
7/16	45,846	1,505,946	3%	91%
7/17	21,462	1,527,408	1%	92%
7/18	10,548	1,537,956	1%	93%
7/19	3,048	1,541,004	0%	93%
7/20	6,348	1,547,352	0%	94%
7/21	8,688	1,556,040	1%	94%
7/22	24,810	1,580,850	2%	96%
7/23	25,434	1,606,284	2%	97%
7/24	22,674	1,628,958	1%	99%
7/25	12,528	1,641,486	1%	99%
7/26	10,086	1,651,572	1%	100%
Total	1,651,572			

[a] July 10 LB hours 2-5 and RB hours 3 & 5 the counts were not completed. On July 13 LB hours 0 & 1 fish not visible. On July 13 both LB & RB from hours 2-6 high winds prevented counting.

Table 16. Daily sockeye salmon tower counts, Wood River, 1999.

Date	Daily Counts	Cumulative Total	Daily % of Total	Cumulative %
6/23	186	186	0%	0%
6/24	5,442	5,628	0%	0%
6/25	2,676	8,304	0%	1%
6/26	1,860	10,164	0%	1%
6/27	10,086	20,250	1%	1%
6/28	15,180	35,430	1%	2%
6/29	10,218	45,648	1%	3%
6/30	27,972	73,620	2%	5%
7/1	17,592	91,212	1%	6%
7/2	87,390	178,602	6%	12%
7/3	347,124	525,726	23%	35%
7/4	214,188	739,914	14%	49%
7/5	234,300	974,214	15%	64%
7/6	107,280	1,081,494	7%	72%
7/7	78,492	1,159,986	5%	77%
7/8	47,634	1,207,620	3%	80%
7/9	28,314	1,235,934	2%	82%
7/10	23,130	1,259,064	2%	83%
7/11	96,810	1,355,874	6%	90%
7/12	33,366	1,389,240	2%	92%
7/13	22,950	1,412,190	2%	93%
7/14	30,810	1,443,000	2%	95%
7/15	11,034	1,454,034	1%	96%
7/16	14,550	1,468,584	1%	97%
7/17	10,410	1,478,994	1%	98%
7/18	8,016	1,487,010	1%	98%
7/19	4,008	1,491,018	0%	99%
7/20	6,264	1,497,282	0%	99%
7/21	5,748	1,503,030	0%	99%
7/22	6,348	1,509,378	0%	100%
7/23	3,048	1,512,426	0%	100%
Total	1,512,426			

Table 17. Historical tower counts of chinook salmon in Bristol Bay from 1974-1997.

YEAR	Egegik	Kvichak	Naknek	Ugashik	Igushik	Nuyakuk
1974						1,590
1975					24	1,686
1976					216	2,490
1977					18	996
1978					18	258
1979					-	504
1980					174	3,814
1981					12	5,460
1982					-	6,198
1983					84	2,958
1984					78	3,246
1985					132	2,628
1986	6		12		48	624
1987			12		36	120
1988	18		144		6	450
1989	12		48		48	
1990	24	42	66		186	
1991		54	42	78	36	
1992		96	30	90		
1993	6	162	174	102	18	
1994	36	132	42	66	210	
1995	60	84	222	24	24	1,380
1996	78		66	60	18	1,404
1997	30	342	180	144	474	3,264

Table 18. Historical tower counts of chum salmon in Bristol Bay from 1974-1997.

YEAR	Egegik	Kvichak	Naknek	Ugashik	Igushik	Nuyakuk
1974						2,058
1975					18	1,518
1976					456	4,434
1977					162	6,882
1978					282	2,856
1979					6	810
1980					1,008	6,522
1981					456	4,824
1982					354	7,374
1983					36	7,224
1984					144	8,652
1985					684	3,774
1986					42	5,634
1987			36		156	972
1988	6		36		60	4,609
1989			18		120	
1990	72	6	6		24	
1991		48	24	90	-	
1992		42	6	60		
1993		84		6	12	
1994	42	30		36	126	
1995	144	24		6	234	7,452
1996				138	438	12,648
1997			6	30	48	7,842

Table 19. Historical tower counts of pink salmon in Bristol Bay from 1974-1997.

YEAR	Egegik	Kvichak	Naknek	Ugashik	Igushik	Nuyakuk
1974						456,216
1975					150	-
1976					2,070	701,478
1977					102	-
1978					210	7,190,184
1979					-	12
1980					600	2,536,746
1981					2,220	252
1982					4,494	1,537,716
1983					6	
1984					1,692	2,602,182
1985					-	918
1986			3		36	
1987			12		18	-
1988			348		18	2,484
1989			234		96	
1990			302		648	
1991		96	318	660	-	
1992	6	78	342	1,728		
1993		36	168	72		
1994	17,994	66	672	300	438	
1995	24	30	96	36	6	-
1996	103,110		396	66	666	1,680
1997			12	61	6	12

Table 20. Historical tower counts of coho salmon in Bristol Bay from 1974-1997.

YEAR	Egegik	Kvichak	Naknek	Ugashik	Igushik	Nuyakuk
1974						
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994	8,724					
1995	7,470					
1996	24,918					
1997						

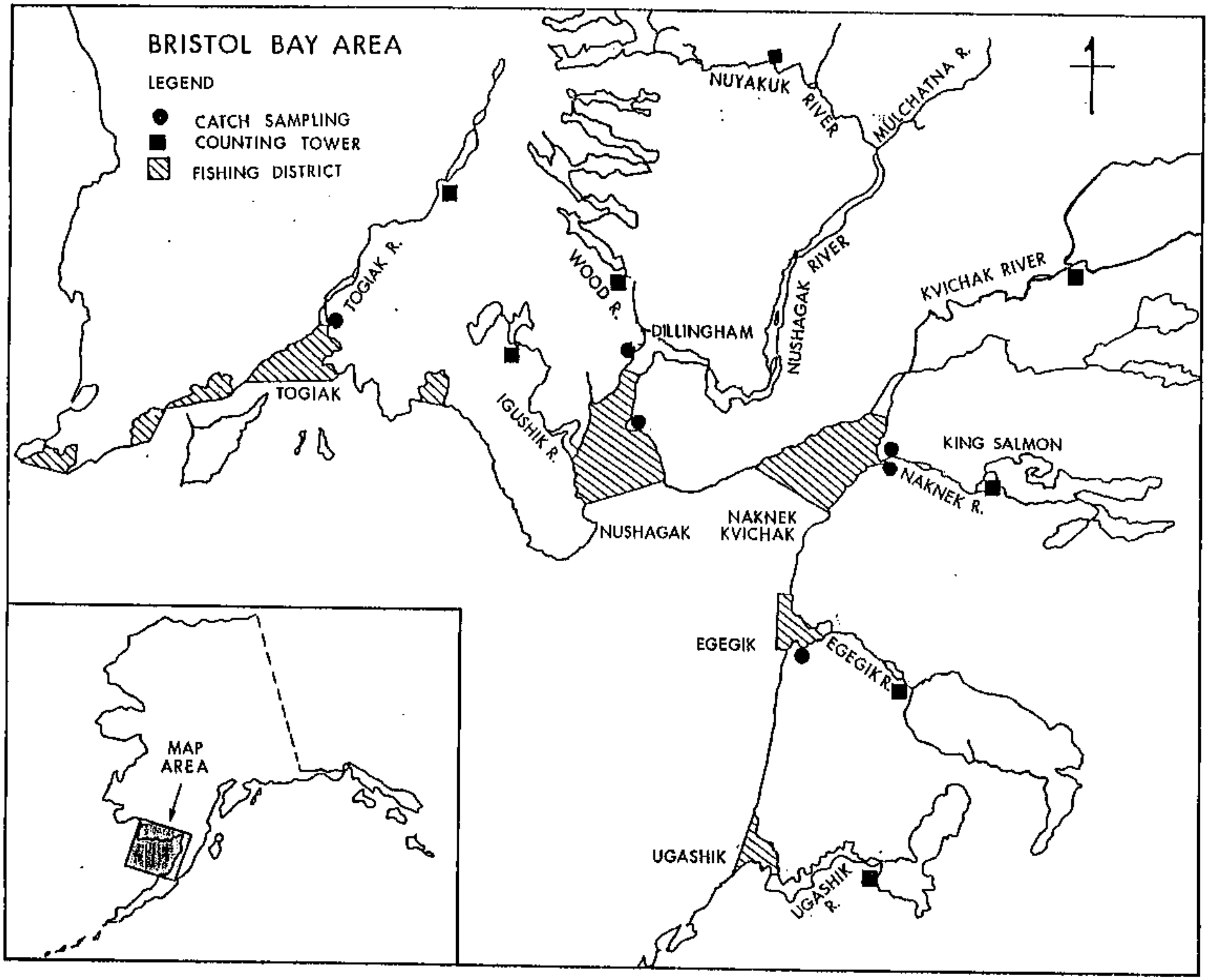

Figure 1. Bristol Bay major river systems and commercial fishing districts.

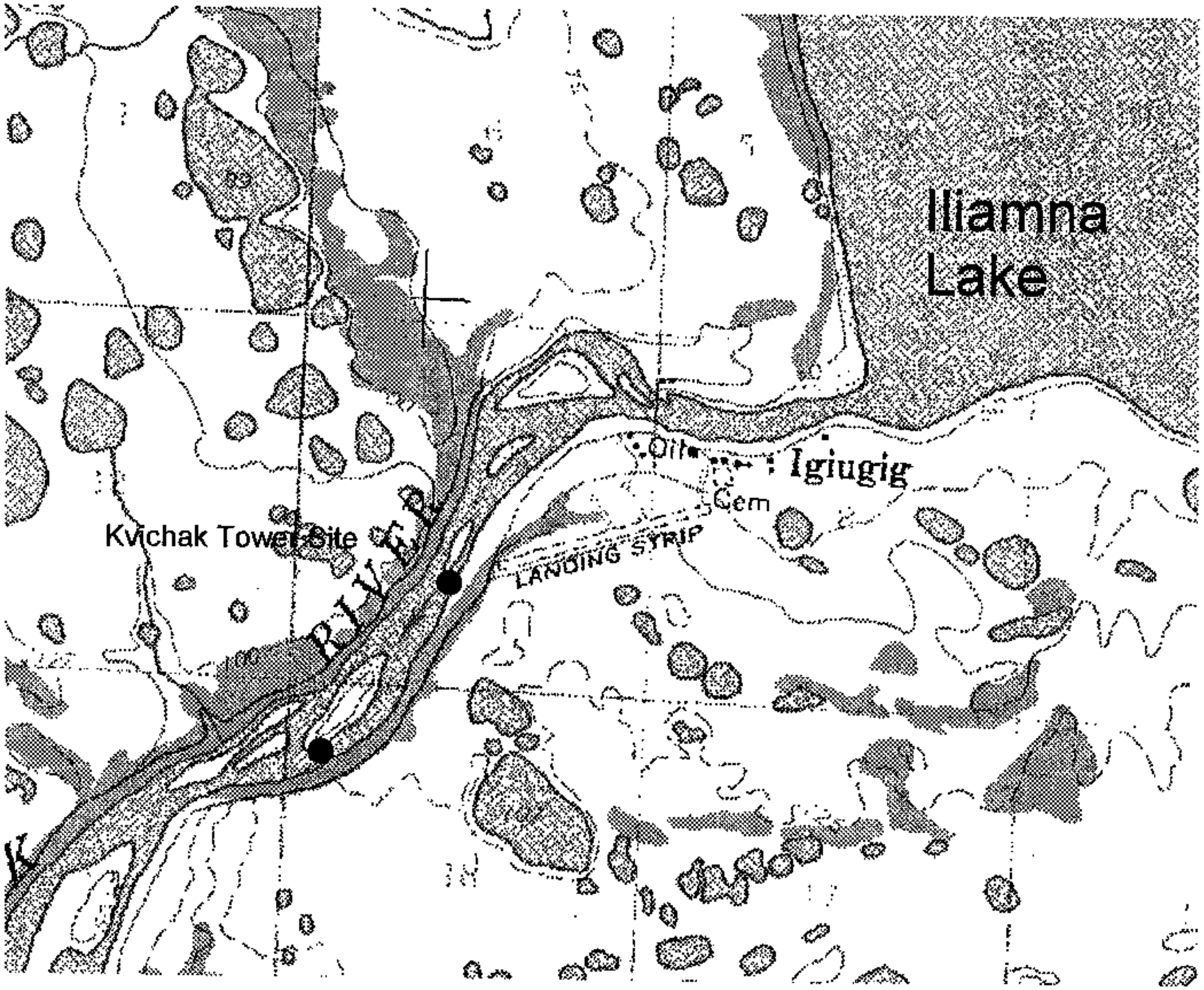

Figure 2. Kvichak River Tower Site, Bristol Bay, Alaska.

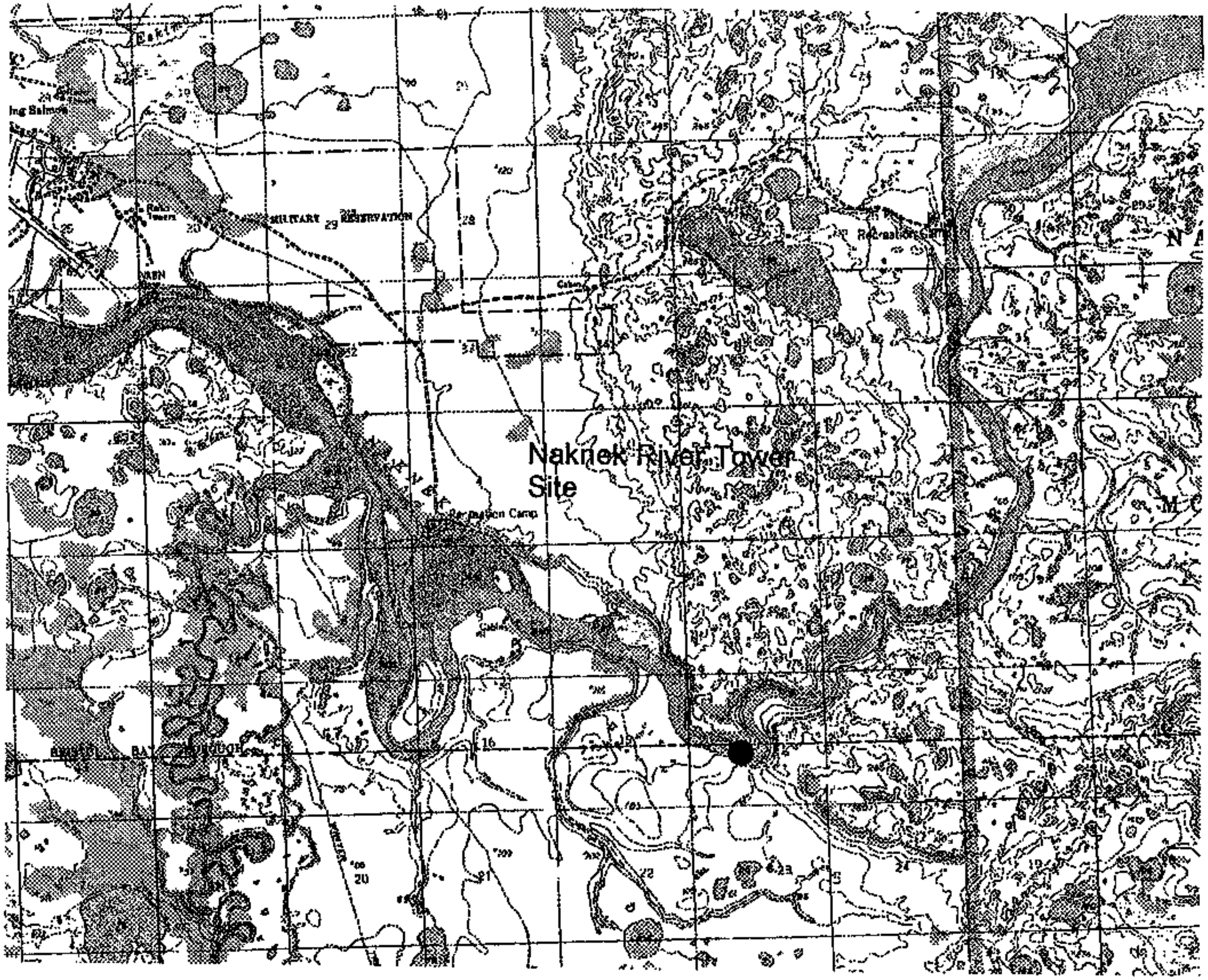

Figure 3. Naknek River Tower Site, Bristol Bay, Alaska.

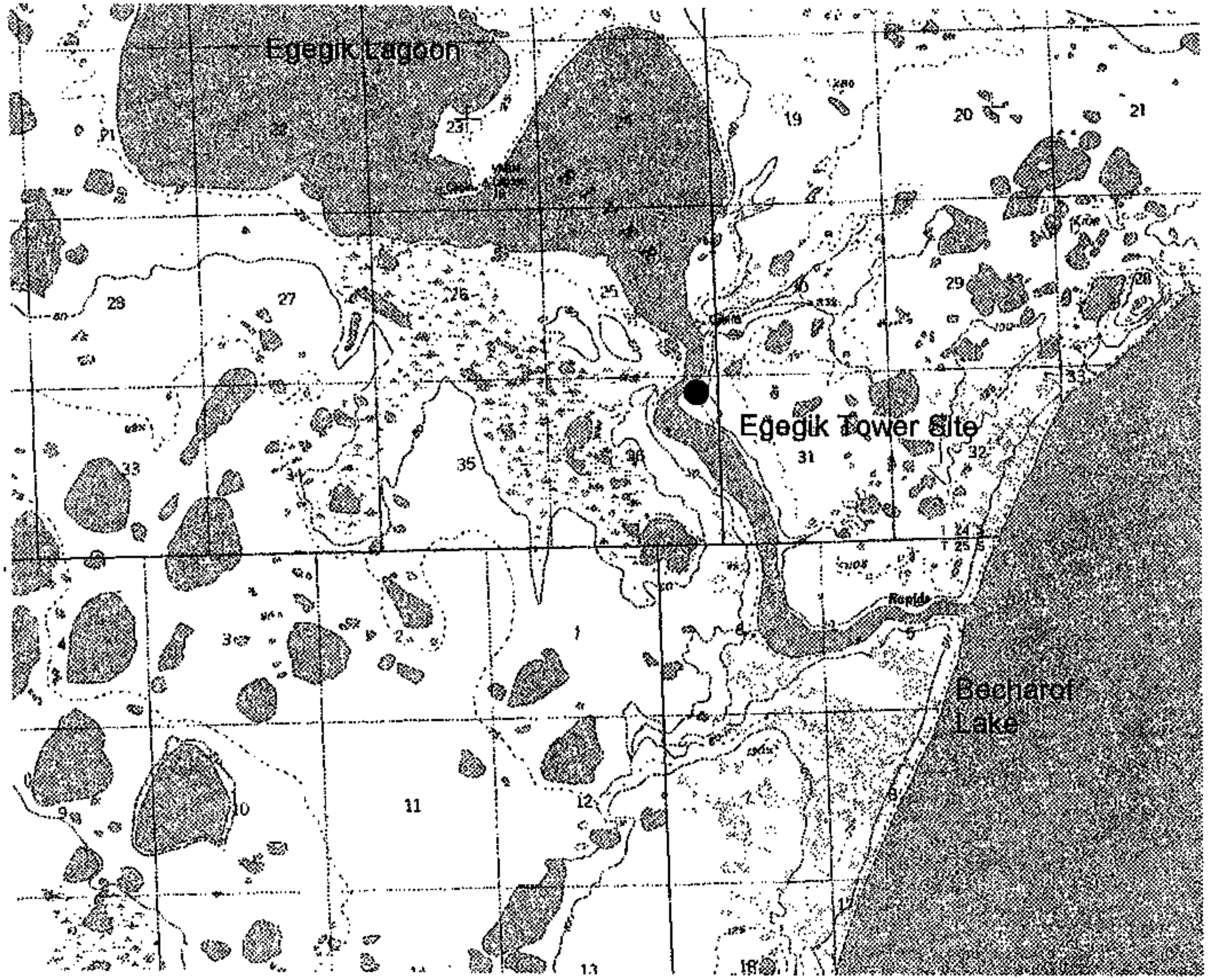

Figure 4. Egegik River Tower Site, Bristol Bay, Alaska.

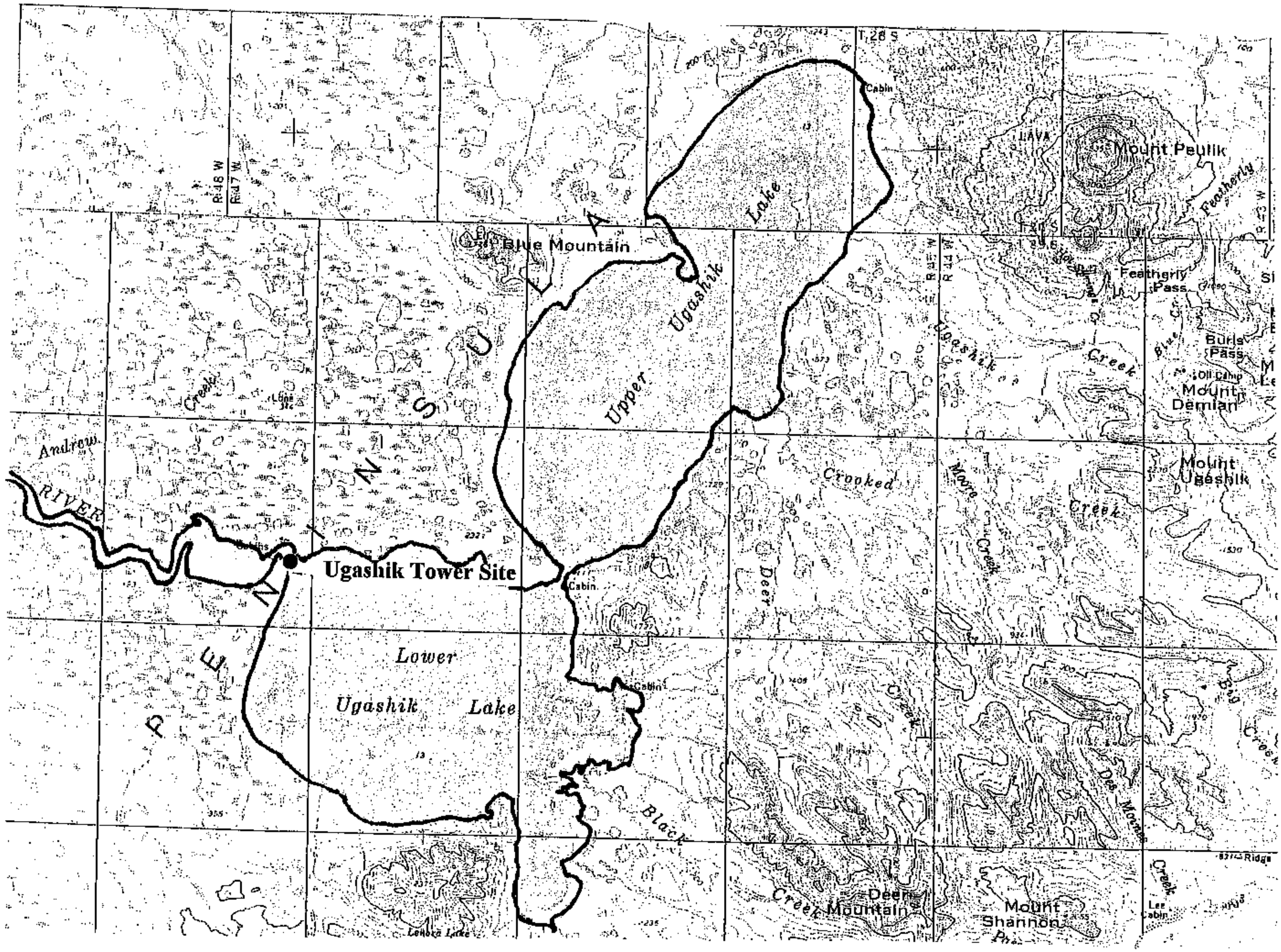

Figure 5. Ugashik River Tower Site, Bristol Bay, Alaska.

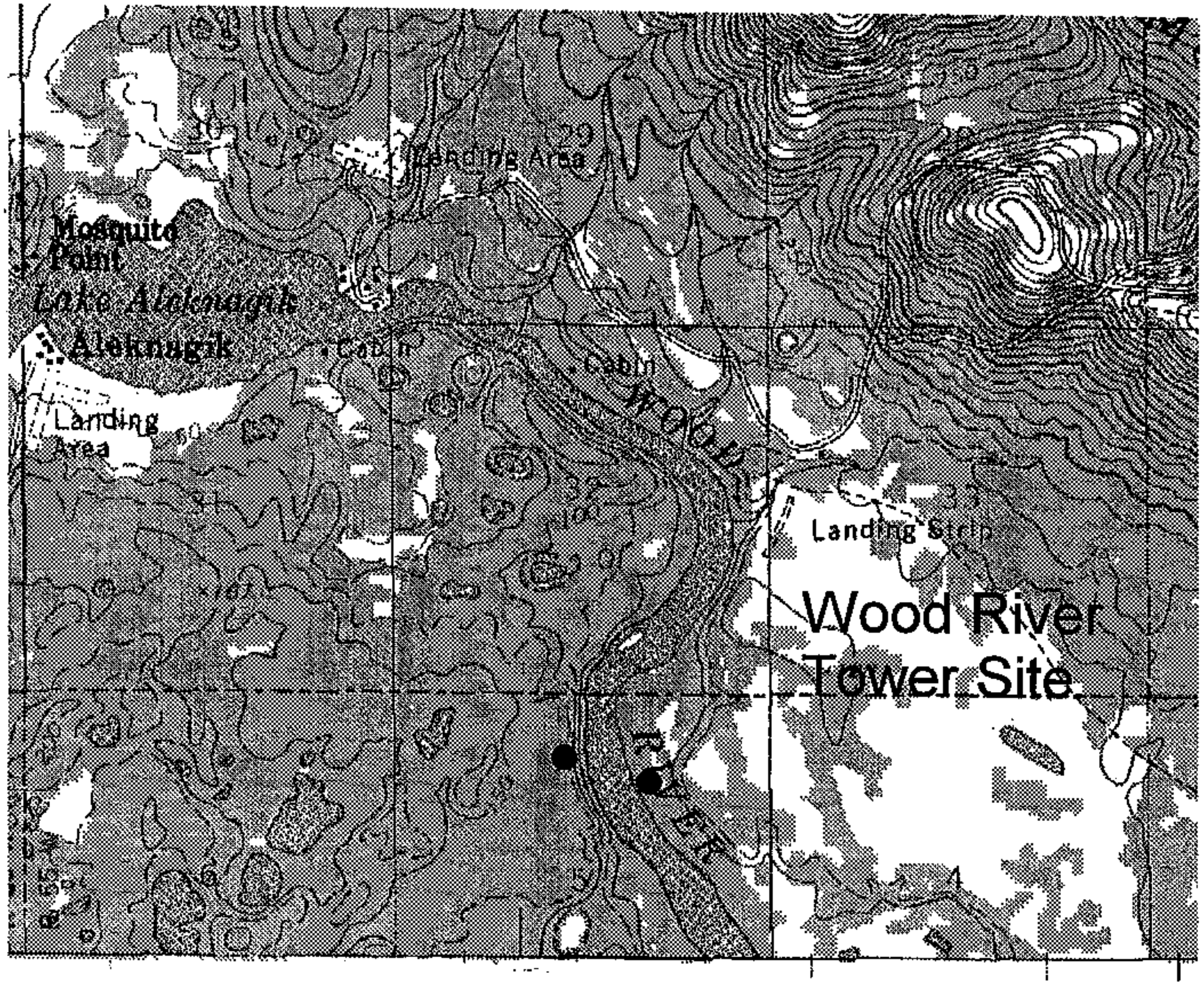

Figure 6. Wood River Tower Site, Bristol Bay, Alaska.

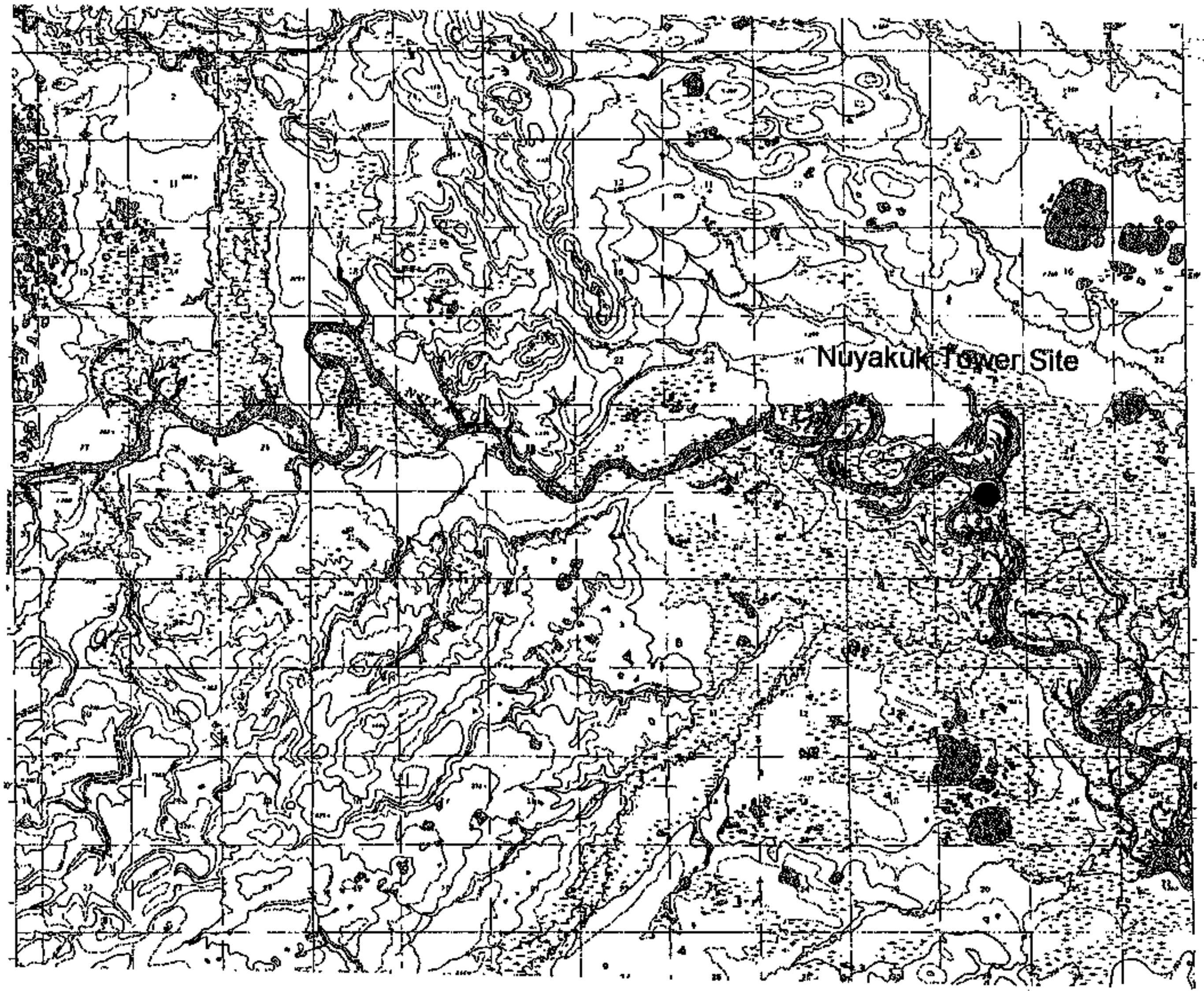

Figure 7. Nuyakuk River Tower Site, Bristol Bay, Alaska.

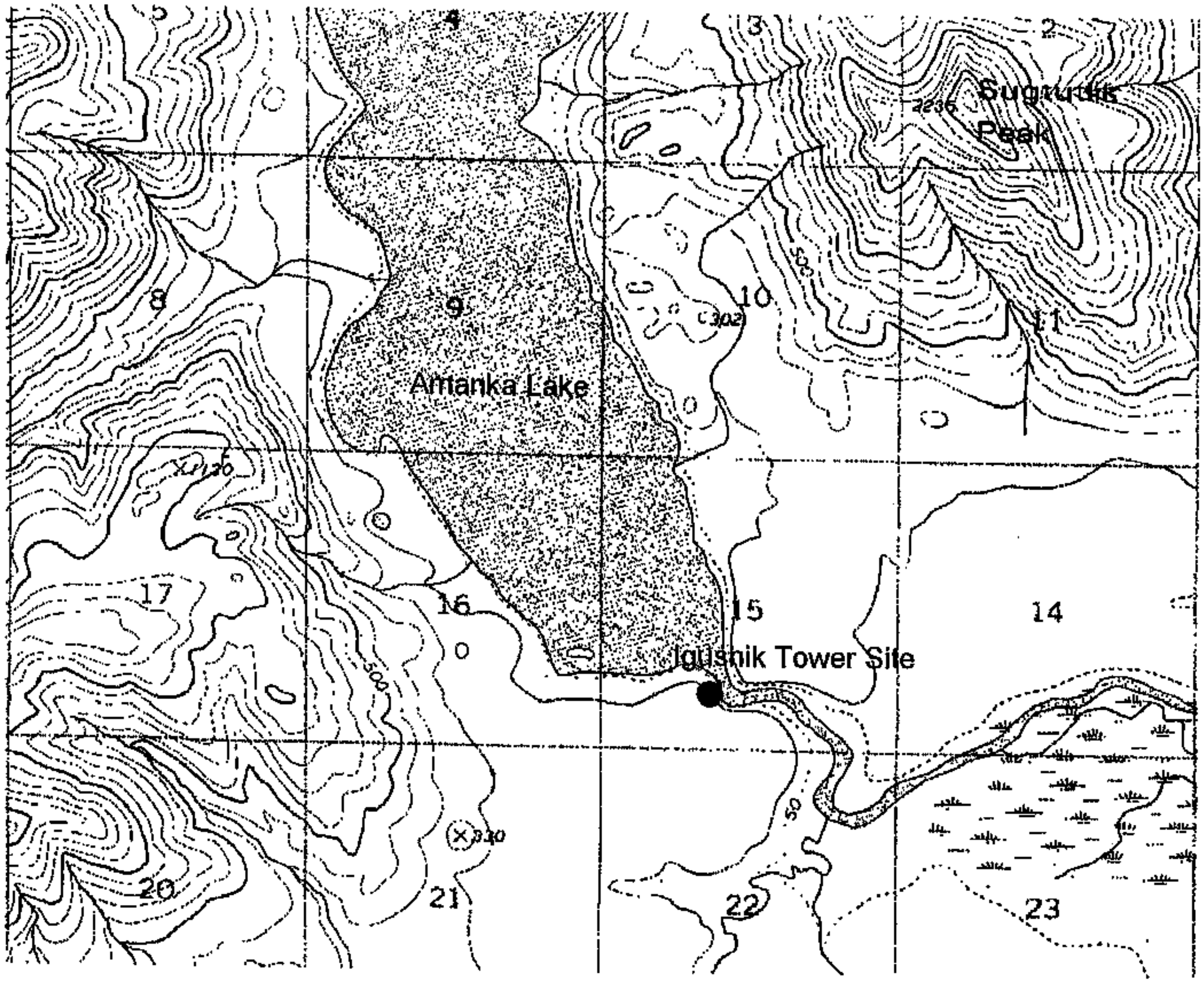

Figure 8. Igushik River Tower Site, Bristol Bay, Alaska.

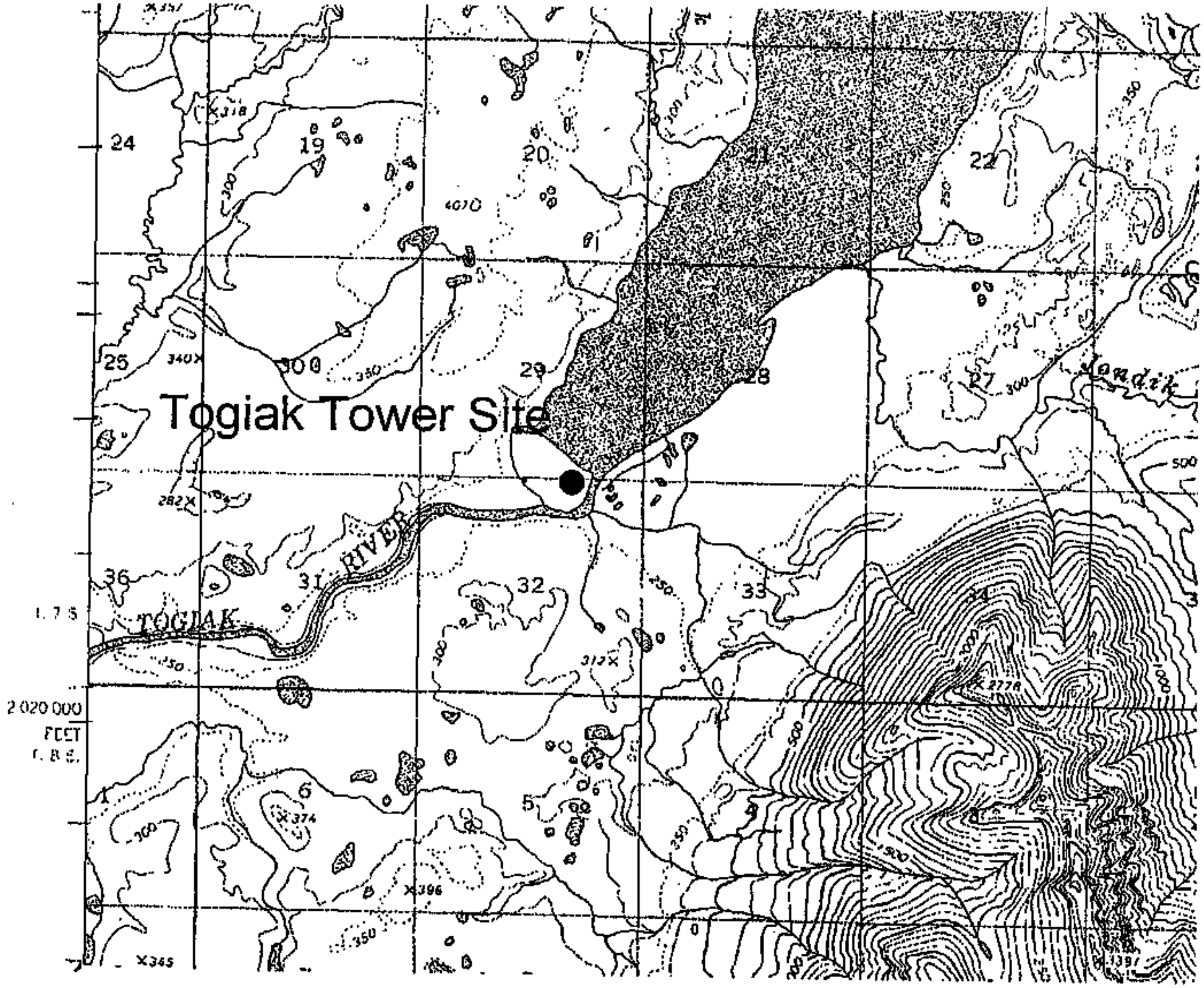

Figure 9. Togiak River Tower Site, Bristol Bay, Alaska.

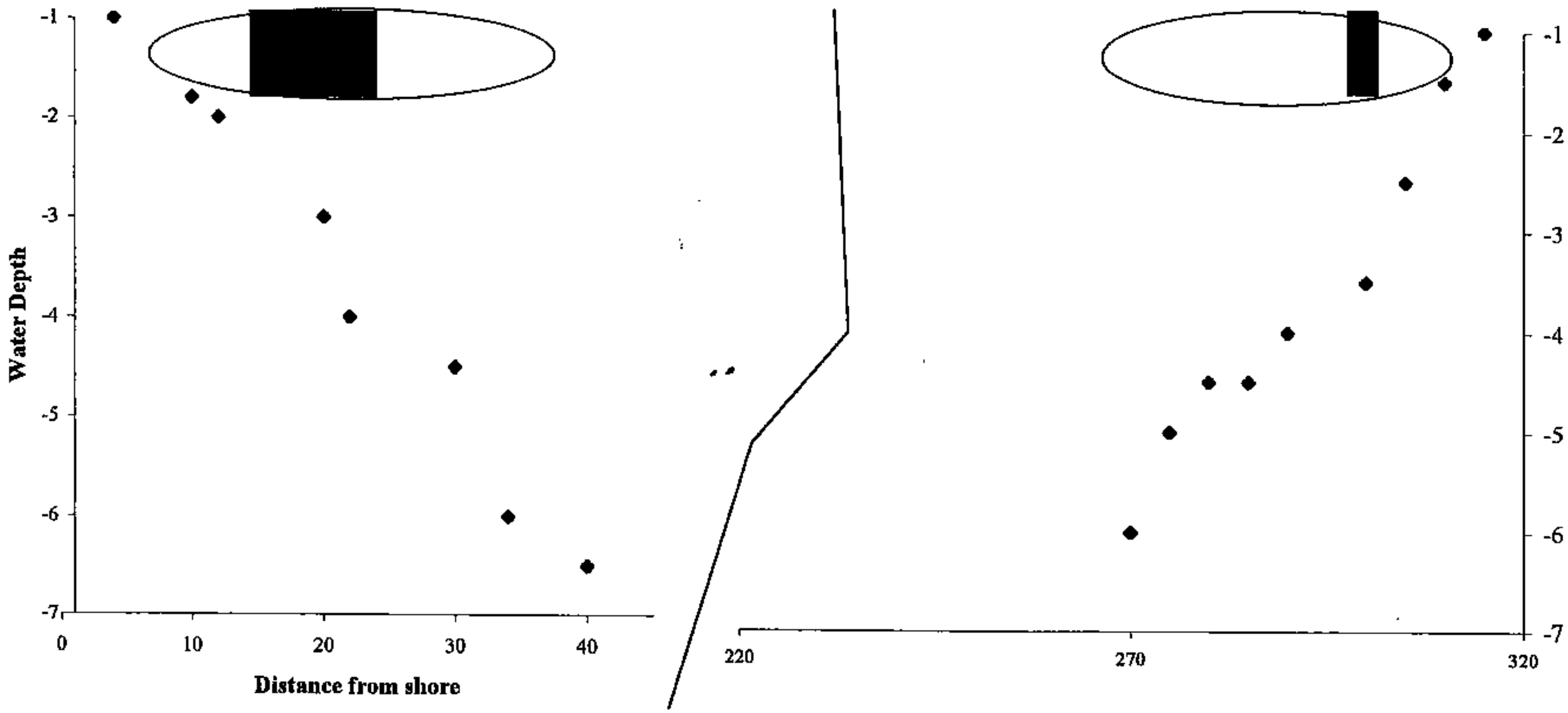

Figure 10. 1999 Wood River tower site bottom profile and fish passage corridor. Elipse represents range of fish passage with black boxes representing area of greatest passage.

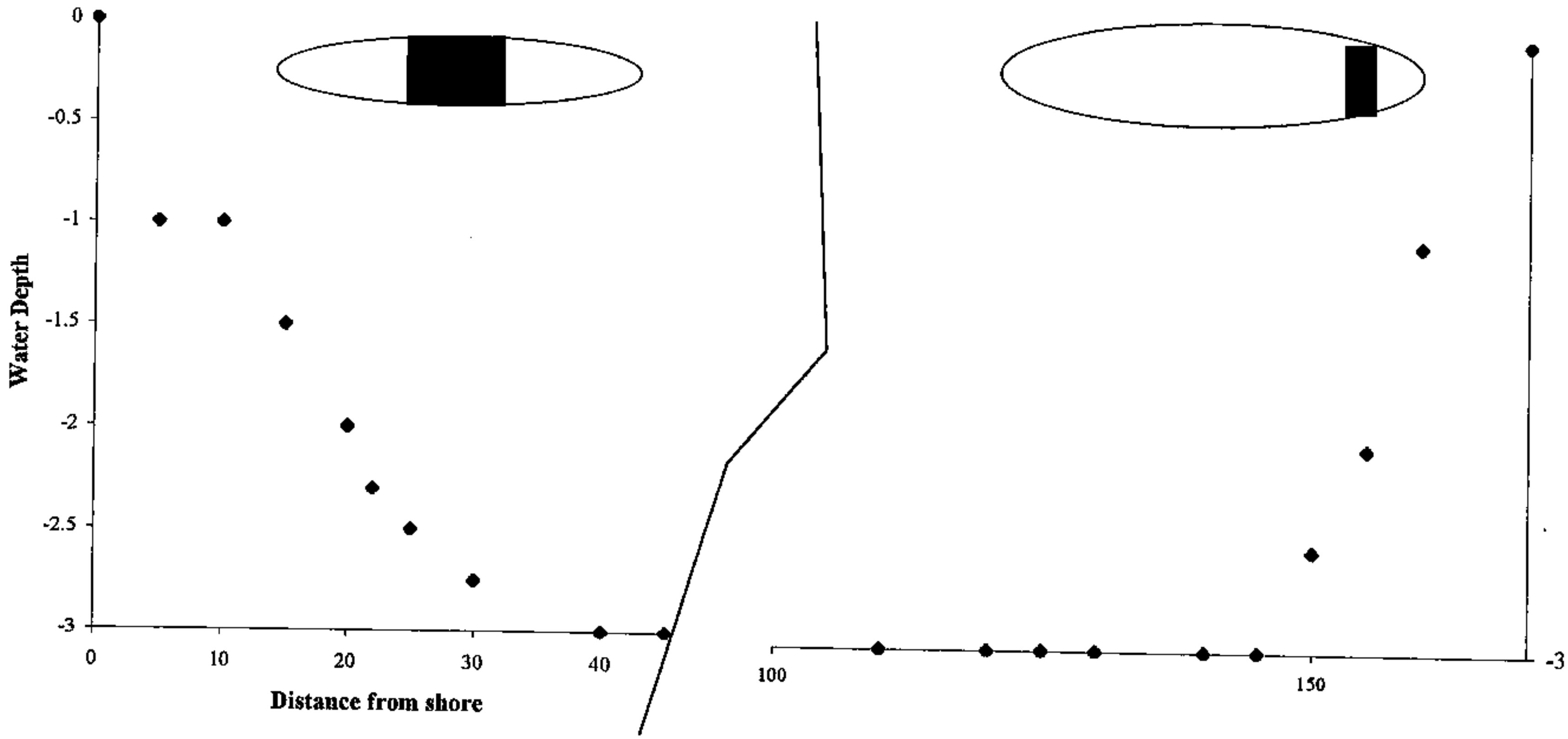

Figure 11. 1999 Igushik River tower site bottom profile and fish passage corridor. Elipse represents range of fish passage with black boxes representing area of greatest passage.

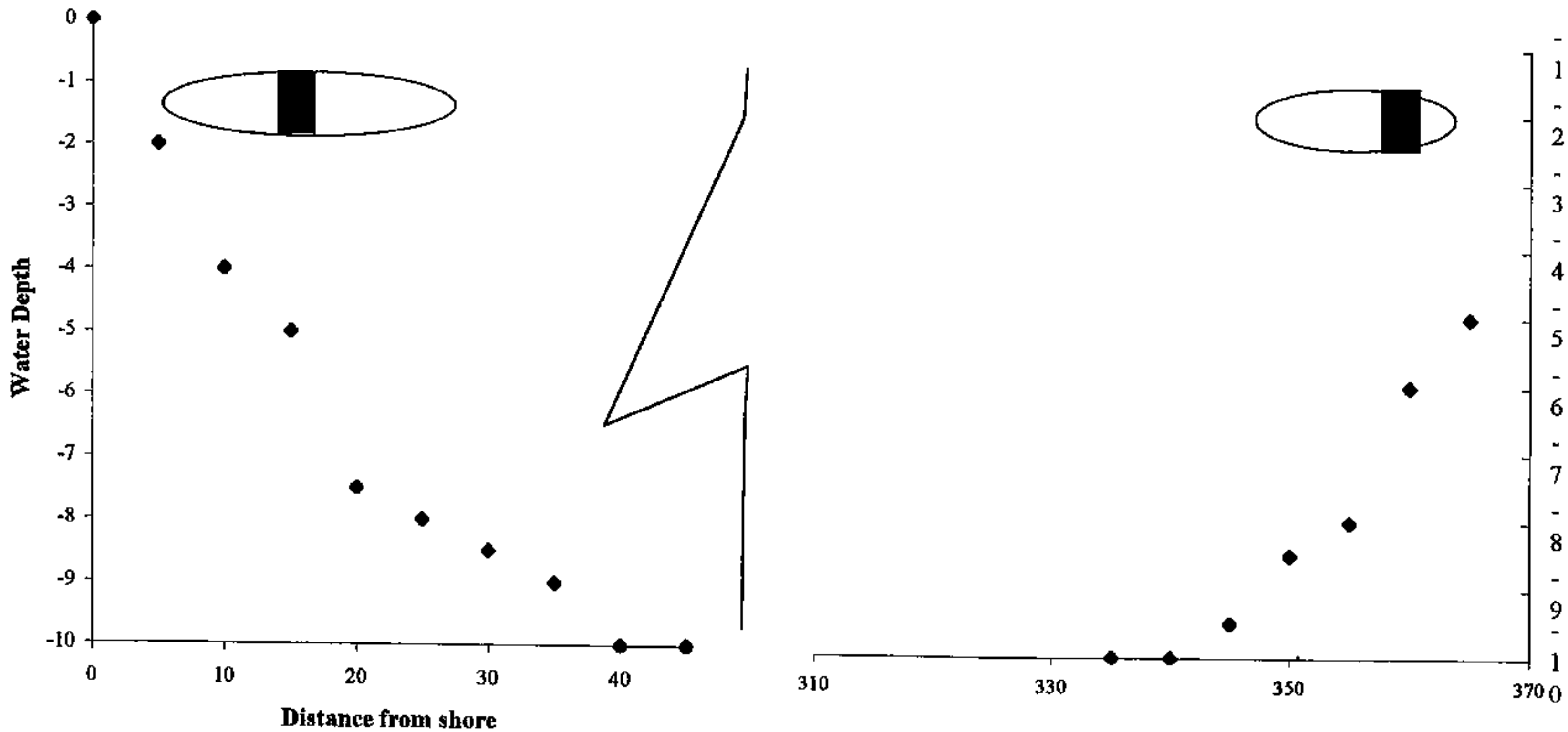

Figure 12. 1999 Nuyakuk River tower site bottom profile and fish passage corridor. Elipse represents range of fish passage with black boxes representing area of greatest passage.

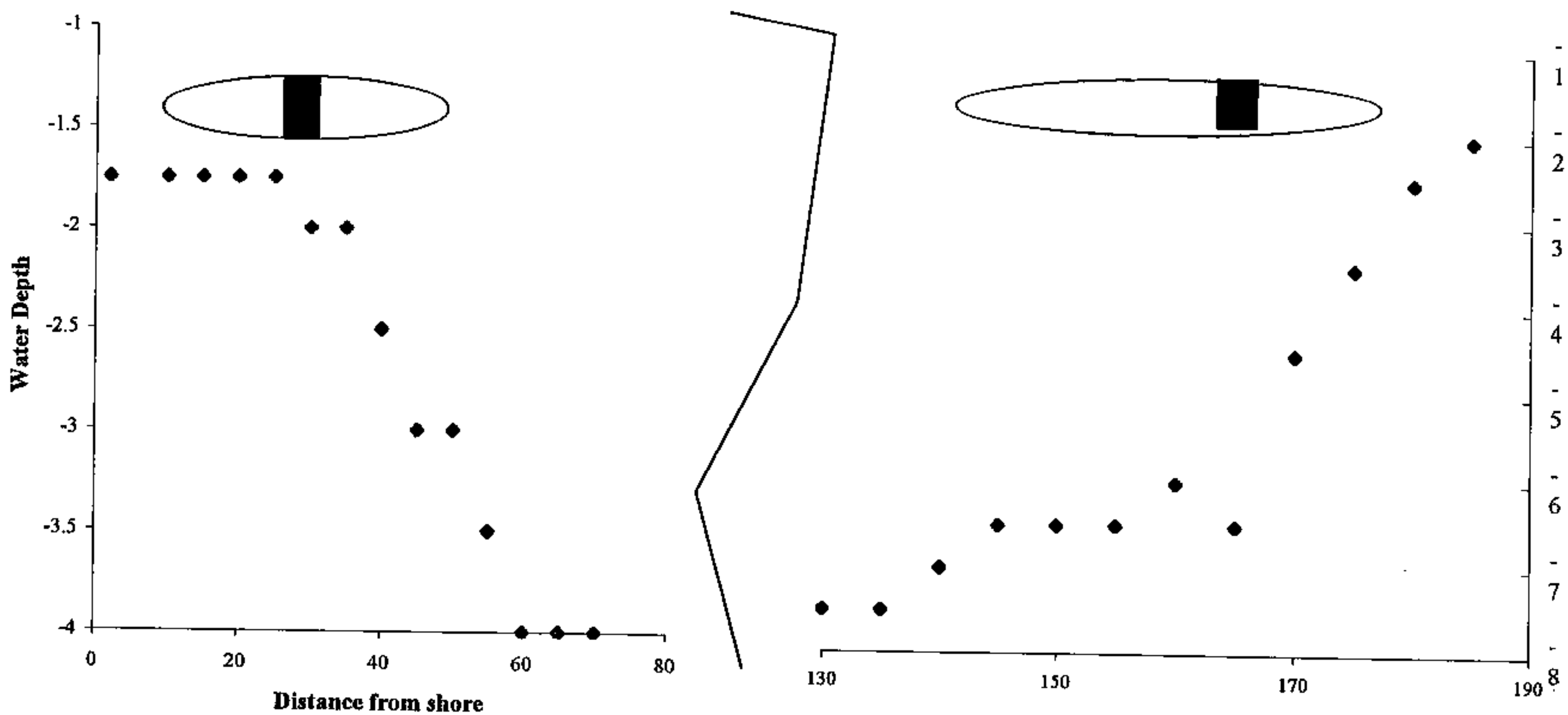

Figure 13. 1999 Togiak River tower site bottom profile and fish passage corridor. Elipse represents range of fish passage with black boxes representing area of greatest passage.

Appendix A

Historical escapement data for sockeye salmon

Counting towers currently operating in Bristol Bay

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1957	1958	1959	1960	1961	1962	1963
17-Jun							
18-Jun							
19-Jun							
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun							
28-Jun							
29-Jun							
30-Jun		16,212	4,800				
01-Jul	9,960	3,606	4,506	0		26,394	
02-Jul	20,136	7,632	0	0	11,286	38,604	9,798
03-Jul	3,042	7,524	0	0	58,308	76,638	19,266
04-Jul	7,524	13,644	80	0	17,826	46,206	1,044
05-Jul	8,848	30,198	20,348	1,416	17,100	14,124	2,538
06-Jul	5,632	31,872	15,684	108	49,908	59,994	134,832
07-Jul	7,552	27,492	98,920	92,346	74,454	182,160	58,122
08-Jul	13,656	44,490	127,512	62,058	65,562	119,448	55,890
09-Jul	20,826	18,606	90,436	17,778	119,526	112,512	70,098
10-Jul	44,664	8,358	96,960	154,728	62,790	79,254	129,444
11-Jul	85,639	12,042	88,904	193,404	27,414	95,502	18,390
12-Jul	64,132	5,316	17,152	310,710	22,158	93,972	20,628
13-Jul	35,985	1,176	2,216	267,738	9,258	15,618	116,922
14-Jul	8,722	2,094	30,132	68,832	39,228	10,176	200,520
15-Jul	17,179	408	58,544	216,763	9,390	17,856	56,364
16-Jul	21,302	294	86,392	165,102	13,446	26,628	34,416
17-Jul	361	3,534	51,820	137,442	19,626	10,494	13,224
18-Jul	3,783	3,132	106,704	33,792	18,348	1,482	5,778
19-Jul	4,596	924	21,840	43,890	23,220	270	510
20-Jul	3,063	1,308	51,512	20,136	17,658	114	186
21-Jul	120	288	25,540	12,108	4,944	36	654
22-Jul	1,169	1,362	21,352	402	558		246
23-Jul	681	1,302	8,940	6	2,472		1,530
24-Jul	1,205	264	5,596	0	9,258		3,228
25-Jul	801	432	1,156	0	3,564		4,362
26-Jul	154	570	4,624	0	1,404		3,888
27-Jul	295	1,266	2,404		450		786
28-Jul	42	432	6,544		612		26,568
29-Jul	42	30	1,412		366		4,440
30-Jul	96	174	741		228		3,078
31-Jul		198	48		378		480
01-Aug		114	0		294		240
02-Aug		60			246		132
03-Aug					132		
04-Aug					126		
Late							
Total	391,207	246,354	1,052,819	1,798,759	701,538	1,027,482	997,602

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1964	1965	1966	1967	1968	1969	1970
17-Jun							
18-Jun							
19-Jun							
20-Jun							
21-Jun							
22-Jun							
23-Jun					48		
24-Jun				18	72		
25-Jun			6	3,684	324		
26-Jun			0	1,614	60		
27-Jun			0	4,044	8		
28-Jun			0	7,032	1,416		
29-Jun			12	3,180	13,038		
30-Jun			0	60	10,680	1,212	
01-Jul		66	270	34,890	17,076	276	1,836
02-Jul	204	8,538	9,762	92,106	33,378	11,028	14,004
03-Jul	2,130	22,548	84,054	27,438	36,846	33,672	15,606
04-Jul	24	37,968	52,248	67,680	34,626	49,650	63,486
05-Jul	10,446	35,514	72	56,898	36,762	29,190	37,482
06-Jul	12,582	91,134	0	88,206	47,886	78,288	25,878
07-Jul	23,490	208,248	3,774	32,226	12,942	132,060	52,038
08-Jul	87,180	232,536	139,656	15,060	24,024	166,698	133,614
09-Jul	89,814	28,692	239,382	39,870	34,482	154,140	66,300
10-Jul	38,250	94,806	126,102	61,752	7,560	36,648	260,610
11-Jul	177,408	146,598	42,708	35,064	6,558	51,696	195,174
12-Jul	134,940	104,880	4,206	24,966	5,436	61,962	10,206
13-Jul	135,006	109,086	51,306	16,212	4,344	57,528	6,684
14-Jul	41,766	49,566	20,544	7,038	456	73,968	8,310
15-Jul	48,318	84,330	12,264	4,158	1,206	30,168	4,176
16-Jul	32,994	94,290	8,172	2,448	570	37,698	2,886
17-Jul	7,764	38,874	786	462	2,340	8,328	2,622
18-Jul	5,760	18,210	1,896	2,748	582	1,122	3,432
19-Jul	1,320	20,706	1,152	1,248	2,190	186	5,562
20-Jul	66	7,242	2,436	1,776	1,122	36	5,208
21-Jul	84	4,518	2,088	3,102	450		1,362
22-Jul	24	5,340	576	1,116	474		1,020
23-Jul	6	732	708	540	690		624
24-Jul		186	66	132	684		282
25-Jul				60	270		516
26-Jul				36	54		702
27-Jul							78
28-Jul							36
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
Late							
Total	849,576	1,444,608	804,246	636,864	338,654	1,015,554	919,734

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1971	1972	1973	1974	1975	1976	1977
17-Jun							
18-Jun							
19-Jun							
20-Jun	0	0	0	0			
21-Jun	0	0	0	0			0
22-Jun	0	0	0	0			822
23-Jun	0	0	0	0		0	9,594
24-Jun	0	0	0	0	0	0	4,668
25-Jun	0	0	0	0	0	0	5,004
26-Jun	0	0	0	78	0	0	8,958
27-Jun	0	0	0	204	0	0	15,270
28-Jun	0	0	3,330	1,350	0	0	29,070
29-Jun	0	0	6,252	3,396	0	0	37,698
30-Jun	0	0	5,616	8,130	0	54	61,320
01-Jul	0	0	15,990	17,040	876	24	49,248
02-Jul	0	0	8,646	67,950	3,750	246	87,726
03-Jul	0	36	10,944	151,800	7,482	6,324	77,100
04-Jul	0	3,192	9,360	83,034	44,154	15,126	21,252
05-Jul	0	498	15,528	112,956	78,834	5,442	91,314
06-Jul	0	70,212	588	112,050	115,596	28,284	97,626
07-Jul	0	124,416	264	154,716	21,954	41,946	32,262
08-Jul	0	71,544	36	117,348	90,678	36,678	16,998
09-Jul	18	82,380	39,924	49,632	179,226	13,824	12,528
10-Jul	336	92,298	28,098	58,224	225,348	22,782	9,552
11-Jul	22,968	44,628	26,622	93,894	47,472	14,790	8,652
12-Jul	53,952	41,256	48,996	67,062	59,028	82,602	2,280
13-Jul	32,562	4,446	28,506	82,530	119,244	63,084	3,078
14-Jul	3,432	6,360	39,750	45,450	72,126	34,038	3,696
15-Jul	2,520	3,522	9,552	18,978	27,300	14,334	3,078
16-Jul	46,788	1,386	9,366	7,008	34,026	4,842	1,632
17-Jul	121,962	120	8,790	11,604	5,004	2,490	2,088
18-Jul	55,482	108	2,082	3,534	3,450	14,910	
19-Jul	4,044		378	1,164	10,092	24,708	
20-Jul	73,842		240	1,014	15,900	61,116	
21-Jul	23,856		4,152	684	6,036	2,334	
22-Jul	46,326		1,212	564	4,656	8,862	
23-Jul	139,362		822	996	1,512	4,500	
24-Jul	5,106		1,266	348	96	1,764	
25-Jul	402		2,514	438		1,842	
26-Jul	1,014		24	726		1,434	
27-Jul	42		-6	1,152		780	
28-Jul				468			
29-Jul				108			
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
Late							
Total	634,014	546,402	328,842	1,275,630	1,173,840	509,160	692,514

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1978	1979	1980	1981	1982	1983	1984
17-Jun	0	0		2,076			0
18-Jun	408	840		3,828			0
19-Jun	918	432		1,794			2,814
20-Jun	1,824	1,074	0	-6	0		4,260
21-Jun	966	9,828	0	18	24	240	10,482
22-Jun	2,718	5,256	0	0	180	4,950	2,340
23-Jun	1,476	6,732	0	912	24	786	5,838
24-Jun	826	8,784	0	14,166	54	2,352	936
25-Jun	3,488	2,100	0	28,248	6	7,656	3,054
26-Jun	5,748	23,310	0	22,758	6	12,192	4,782
27-Jun	5,076	65,802	0	15,642	0	25,512	19,530
28-Jun	10,140	65,556	0	14,700	648	63,360	30,186
29-Jun	11,952	169,158	0	1,956	720	156,672	37,554
30-Jun	47,808	82,296	12	3,174	234	168,462	46,644
01-Jul	53,376	70,548	0	4,806	1,920	77,466	66,204
02-Jul	57,234	100,554	0	29,520	20,214	54,150	85,866
03-Jul	13,896	99,828	1,746	52,536	-12	14,250	68,694
04-Jul	3,864	64,254	39,990	70,422	7,206	12,888	39,642
05-Jul	12,432	22,392	81,960	99,516	39,198	30,396	41,988
06-Jul	54,210	56,178	25,944	99,630	30,042	25,818	43,032
07-Jul	124,698	25,860	77,232	102,444	51,516	26,184	54,606
08-Jul	177,960	21,498	92,046	50,700	99,258	15,162	88,530
09-Jul	183,300	46,914	36,060	21,810	143,424	10,332	132,762
10-Jul	96,762	29,886	73,794	24,318	184,158	5,220	113,250
11-Jul	6,810	19,062	409,482	5,190	151,122	4,320	115,536
12-Jul	2,496	15,114	10,200	9,534	137,766	4,986	99,180
13-Jul	4,284	6,270	74,964	6,594	98,736	3,234	21,336
14-Jul	4,632	4,590	79,050	2,052	49,746	6,042	6,072
15-Jul	3,012	3,270	16,596	2,994	13,458	6,582	5,910
16-Jul	1,938	3,474	17,364	432	1,164	2,106	4,098
17-Jul	1,446	1,182	13,152	1,614	1,470	2,712	4,548
18-Jul			5,220	1,302	558	6,918	4,315
19-Jul			4,788		870	13,434	965
20-Jul			1,320		918	9,312	366
21-Jul						9,300	
22-Jul						4,446	
23-Jul						2,466	
24-Jul						2,376	
25-Jul							
26-Jul							
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
Late							
Total	895,698	1,032,042	1,060,920	694,680	1,034,628	792,282	1,165,320

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1985	1986	1987	1988	1989	1990	1991
17-Jun							
18-Jun							
19-Jun							
20-Jun					0		
21-Jun			0		13,914	60	
22-Jun	2,388		0	2,508	41,844	24	
23-Jun	2,532	348	174	3,384	34,860	0	2,142
24-Jun	678	1,494	18,786	3,012	5,754	642	7,452
25-Jun	726	4,860	5,622	2,256	11,838	1,194	1,728
26-Jun	1,524	642	60,750	6,912	17,034	1,218	24,210
27-Jun	8,562	9,774	110,226	17,100	7,152	720	10,974
28-Jun	43,848	9,426	51,132	96,108	23,352	5,142	16,866
29-Jun	52,008	9,708	53,718	111,444	14,040	14,832	23,352
30-Jun	75,240	6,252	28,188	66,288	58,980	27,126	47,358
01-Jul	68,814	24,186	83,100	39,348	58,740	41,208	115,764
02-Jul	21,222	27,378	18,702	58,164	70,632	261,582	156,450
03-Jul	109,080	117,360	52,986	109,584	222,378	334,050	300,438
04-Jul	132,306	56,982	37,236	126,168	185,328	349,668	305,238
05-Jul	96,036	138,948	51,618	158,940	217,002	138,978	326,586
06-Jul	154,548	156,888	67,446	135,216	269,502	137,634	345,588
07-Jul	48,036	74,052	80,304	81,666	139,800	73,416	343,284
08-Jul	31,260	31,812	124,248	115,896	115,404	51,636	142,194
09-Jul	22,800	26,586	122,718	64,506	36,774	28,644	68,844
10-Jul	45,684	29,496	64,302	78,918	6,972	68,520	37,368
11-Jul	39,234	46,860	34,734	104,148	8,304	58,986	45,756
12-Jul	63,138	56,814	10,626	42,048	7,062	142,782	85,896
13-Jul	32,598	68,490	10,842	53,796	13,158	119,226	54,942
14-Jul	29,328	73,428	19,932	79,578	5,316	76,122	151,068
15-Jul	5,874	10,062	21,930	9,804	5,094	52,758	96,612
16-Jul	2,442	10,592	33,144	5,466	9,936	118,032	12,366
17-Jul	1,200	10,592	47,244	8,328	1,974	23,718	8,688
18-Jul	1,404	10,592	7,134	10,938	2,286	13,254	10,326
19-Jul	1,836	10,592	20,946	4,662	2,874	13,890	11,118
20-Jul	858	10,592	9,642	1,986	2,034	15,612	11,358
21-Jul		10,592	16,938	924	1,578	5,874	10,488
22-Jul		10,592	6,672			5,034	12,426
23-Jul		10,592	2,154			4,056	
24-Jul		10,592	-216			3,852	
25-Jul		10,592				1,872	
26-Jul		10,592					
27-Jul		10,592					
28-Jul		10,592					
29-Jul		10,592					
30-Jul		10,592					
31-Jul		10,594					
01-Aug							
02-Aug							
03-Aug							
04-Aug							
Late							
Total	1,095,204	1,151,320	1,272,978	1,599,096	1,610,916	2,191,362	2,786,880

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1992	1993	1994	1995[a]	1996	1997	1998
17-Jun							
18-Jun							192
19-Jun		888		456	11,220	14,610	24
20-Jun	1,656	20,454		4,686	10,650	26,100	2,016
21-Jun	9,864	130,842		15,516	90	13,566	1,548
22-Jun	3,204	144,438	816	2,052	1,260	34,830	1,134
23-Jun	14,304	156,192	264	78	21,174	10,572	15,060
24-Jun	15,060	98,718	4,938	3,600	27,378	6,258	21,198
25-Jun	22,032	69,252	32,052	28,476	24,468	6,324	27,474
26-Jun	41,142	110,514	71,178	81,684	2,298	7,410	21,948
27-Jun	118,674	45,246	17,364	88,326	888	25,164	32,394
28-Jun	96,294	19,668	10,890	188,766	37,176	42,636	25,458
29-Jun	130,620	7,032	5,712	115,818	35,868	44,034	50,028
30-Jun	129,990	8,292	35,088	122,076	34,434	34,566	46,242
01-Jul	144,366	27,048	31,410	79,986	36,222	16,296	95,676
02-Jul	45,798	48,972	4,578	6,894	46,038	6,618	85,278
03-Jul	7,692	19,884	29,520	18,528	60,714	13,614	13,620
04-Jul	11,232	24,576	221,826	78,906	31,116	7,956	50,436
05-Jul	53,580	70,542	184,764	56,136	17,202	9,252	14,850
06-Jul	84,240	103,170	178,818	41,226	8,604	18,252	71,016
07-Jul	114,972	61,692	180,138	2,976	34,686	170,664	101,868
08-Jul	89,574	48,240	151,176	65,376	51,342	127,806	36,276
09-Jul	109,764	37,824	176,892	61,818	62,250	39,228	17,262
10-Jul	155,604	30,738	79,404	5,220	234,648	12,252	45,102
11-Jul	146,322	61,938	106,392	23,634	226,074	176,196	59,094
12-Jul	141,642	42,132	100,008	21,480	20,688	81,300	24,276
13-Jul	83,292	44,220	42,348	14,844	2,370	68,130	29,766
14-Jul	24,624	23,886	43,422	11,166	3,270	37,842	63,780
15-Jul	19,812	10,428	50,148	4,362	9,564	42,498	65,088
16-Jul	23,220	9,060	23,088	8,904	17,790	6,168	14,370
17-Jul	30,378	7,086	21,774	10,872	6,114	3,822	20,058
18-Jul	18,198	10,338	45,642	5,850			37,302
19-Jul	24,936	8,172	21,366	7,374			12,570
20-Jul	24,384	9,936	11,622	6,498			8,478
21-Jul	8,862	3,636	15,294	4,290			
22-Jul		1,926		32,268			
23-Jul				24,972			
24-Jul				14,784			
25-Jul				5,964			
26-Jul				1,104			
27-Jul				1,308			
28-Jul				546			
29-Jul				1,032			
30-Jul				1,218			
31-Jul				3,720			
01-Aug				1,140			
02-Aug				660			
03-Aug				672			
04-Aug				342			
Late				4,074			
Total	1,945,332	1,516,980	1,897,932	1,281,678	1,075,596	1,103,964	1,110,882

a Total sockeye for Aug 5-30 when tower operated for coho salmon enumeration.

Appendix A.1. Egegik River historical daily escapement, 1957-1999.

Date	1999
17-Jun	
18-Jun	
19-Jun	
20-Jun	
21-Jun	24
22-Jun	24
23-Jun	66
24-Jun	30
25-Jun	18
26-Jun	78
27-Jun	450
28-Jun	60
29-Jun	2,970
30-Jun	5,598
01-Jul	56,400
02-Jul	61,002
03-Jul	211,962
04-Jul	98,436
05-Jul	99,642
06-Jul	173,484
07-Jul	262,872
08-Jul	163,278
09-Jul	194,010
10-Jul	141,978
11-Jul	90,372
12-Jul	85,824
13-Jul	23,178
14-Jul	16,860
15-Jul	19,572
16-Jul	7,812
17-Jul	11,772
18-Jul	
19-Jul	
20-Jul	
21-Jul	
22-Jul	
23-Jul	
24-Jul	
25-Jul	
26-Jul	
27-Jul	
28-Jul	
29-Jul	
30-Jul	
31-Jul	
01-Aug	
02-Aug	
03-Aug	
04-Aug	
Late	
Total	1,727,772

Appendix A. 2. Igushik River historical daily escapement, 1958-1999.

Date	1958	1959	1960	1961	1962	1963	1964
19-Jun							
20-Jun							
21-Jun							
22-Jun		492					0
23-Jun		897		192			0
24-Jun		804		144			0
25-Jun		1,725	0	162		36	0
26-Jun	1,422	1,110	30	108		0	0
27-Jun	1,596	1,416	48	348		0	0
28-Jun	306	1,593	726	1,812		0	12
29-Jun	2,544	4,281	4,008	5,880		48	12
30-Jun	1,770	9,561	9,048	9,234	204	480	36
01-Jul	2,400	10,977	2,892	12,270	306	252	930
02-Jul	3,108	17,280	4,452	14,220	312	798	168
03-Jul	1,668	28,878	6,747	16,548	564	1,362	9,510
04-Jul	1,746	32,538	8,196	14,070	348	2,364	5,706
05-Jul	5,844	38,754	11,370	18,516	546	1,860	3,264
06-Jul	2,364	55,998	14,442	20,556	708	2,286	3,870
07-Jul	3,810	38,034	13,878	21,030	2,286	8,328	7,980
08-Jul	4,896	35,796	14,352	26,946	3,762	11,982	12,972
09-Jul	10,500	45,915	18,702	20,568	2,628	14,850	13,206
10-Jul	16,410	37,461	34,674	17,946	1,752	12,300	9,174
11-Jul	11,310	31,578	34,812	17,886	720	7,230	7,104
12-Jul	1,932	29,889	45,426	13,980	834	4,392	9,102
13-Jul	3,540	15,042	42,780	11,520	372	3,276	5,646
14-Jul	4,242	11,418	31,314	10,038	90	3,036	5,916
15-Jul	6,444	19,893	25,434	10,212	42	2,700	10,212
16-Jul	3,240	20,475	20,064	5,760	42	2,604	7,878
17-Jul	3,324	16,257	11,892	6,138	54	4,080	4,110
18-Jul	3,768	21,822	17,322	3,564	72	2,196	4,242
19-Jul	2,904	23,571	16,686	2,730	6	1,584	2,646
20-Jul	1,770	22,644	13,872	1,884	0	1,728	1,818
21-Jul	1,338	18,861	13,080	2,130	0	978	882
22-Jul	696	15,906	12,642	1,002	12	570	1,236
23-Jul	978	6,129	12,108	1,146	0	300	636
24-Jul	648	5,520	11,958	36		270	210
25-Jul	372	3,719	8,628	684		102	6
26-Jul	270	2,961	6,582	1,110		150	36
27-Jul	78	1,206	6,156	540		36	12
28-Jul	54	4,635	3,930	390		6	
29-Jul	120	2,946	4,152	630			
30-Jul	66	1,706	3,384	444			
31-Jul	0	1,734	2,094	756			
01-Aug	0	1,069	2,340	414			
02-Aug	0	360	1,590	558			
03-Aug		957	1,296	150			
04-Aug			1,260				
05-Aug			720				
Total	107,478	643,808	495,087	294,252	15,660	92,184	128,532

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Appendix A. 2. Igushik River historical daily escapement, 1958-1999.

Date	1965	1966	1967	1968	1969	1970	1971
19-Jun			0				
20-Jun			0				
21-Jun			0	0			
22-Jun			0	192		258	
23-Jun			12	0		474	
24-Jun	4		1,182	912	0	594	
25-Jun	0		2,388	2,010	564	1,482	
26-Jun	6		5,136	8,052	3,102	2,262	
27-Jun	36		6,396	11,904	10,020	540	
28-Jun	12		7,362	22,416	11,946	1,272	
29-Jun	1,272		5,910	19,836	7,596	252	
30-Jun	3,786		7,698	16,362	8,172	294	
01-Jul	3,792		8,064	22,170	8,694	384	
02-Jul	7,182	842	12,660	16,632	8,064	1,470	
03-Jul	4,962	1,122	25,158	16,362	17,292	594	36
04-Jul	2,760	96	26,616	12,258	36,234	3,906	1,950
05-Jul	2,940	48	22,188	6,414	44,988	3,426	2,742
06-Jul	1,440	108	30,792	5,988	45,552	7,860	5,832
07-Jul	1,002	36,138	22,938	6,360	60,342	17,844	5,472
08-Jul	8,474	35,154	25,284	5,928	65,316	40,962	5,820
09-Jul	20,946	43,002	18,744	3,660	64,842	55,146	5,748
10-Jul	27,606	16,236	13,296	4,626	37,008	39,966	3,354
11-Jul	29,712	5,868	12,456	(180)	21,162	34,662	1,056
12-Jul	28,140	4,608	3,906	2,004	15,030	36,948	1,044
13-Jul	14,106	7,506	3,114	2,940	12,246	41,946	684
14-Jul	7,026	18,030	1,134	1,092	9,738	35,844	2,580
15-Jul	2,352	17,856	2,736	(54)	7,668	24,336	7,248
16-Jul	1,542	9,948	2,886	846	5,226	9,672	12,912
17-Jul	1,668	2,940	4,218	348	4,956	4,878	9,210
18-Jul	1,644	1,956	2,094	(1,104)	3,678	996	978
19-Jul	2,340	1,146	1,566	162	2,118	900	19,950
20-Jul	1,722	1,530	1,830	1,698	738	534	20,070
21-Jul	1,656	918	1,512	1,530	36	264	4,530
22-Jul	780	552	438	(396)		954	21,108
23-Jul	258	516	120	1,506			(660)
24-Jul	648	240	762	1,716			48,456
25-Jul	408		738	318			21,498
26-Jul	414		384				7,302
27-Jul	186		54				1,758
28-Jul	18						240
29-Jul							42
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	180,840	206,360	281,772	194,508	512,328	370,920	210,960

Appendix A. 2. Igushik River historical daily escapement, 1958-1999.

Date	1972	1973	1974	1975	1976	1977	1978
19-Jun							
20-Jun							
21-Jun							
22-Jun			108	0	0	0	
23-Jun			0	0	0	0	1,896
24-Jun			480	0	0	384	5,142
25-Jun			354	0	0	516	4,338
26-Jun		18	456	0	36	408	10,290
27-Jun		0	816	0	0	660	9,948
28-Jun		0	1,266	0	156	1,812	9,930
29-Jun		0	1,260	0	0	2,388	9,564
30-Jun		0	1,224	0	600	3,342	18,978
01-Jul		0	2,700	0	828	4,116	24,252
02-Jul		10,572	6,486	0	324	4,428	27,222
03-Jul		5,256	14,802	0	1,632	2,730	24,528
04-Jul	84	5,058	21,702	0	1,812	2,982	29,076
05-Jul	1,164	4,926	36,150	1,032	2,460	3,912	37,068
06-Jul	1,242	4,158	49,548	1,710	5,364	3,510	45,126
07-Jul	276	2,928	45,834	5,478	13,668	2,790	37,788
08-Jul	480	996	39,384	22,308	13,578	9,408	46,914
09-Jul	2,724	1,056	20,028	36,084	11,664	13,242	24,498
10-Jul	3,708	1,212	16,830	25,692	12,564	7,422	32,280
11-Jul	4,500	4,224	12,582	32,616	14,640	9,054	32,484
12-Jul	6,042	6,192	16,956	37,662	20,166	5,838	27,564
13-Jul	5,934	4,890	14,922	20,724	13,824	3,570	28,932
14-Jul	6,912	2,076	10,770	12,054	9,822	2,400	20,118
15-Jul	5,184	2,454	7,068	9,270	8,460	3,402	12,222
16-Jul	5,988	1,230	6,282	6,792	6,510	2,814	5,826
17-Jul	4,020	1,044	6,132	4,524	8,496	1,404	3,426
18-Jul	2,592	450	6,216	6,930	11,202	1,206	2,178
19-Jul	3,078	102	7,074	4,698	7,338	612	2,064
20-Jul	2,928	492	4,446	4,488	4,884	630	1,854
21-Jul	1,398	156	2,376	3,468	6,792	648	648
22-Jul	744	18	1,530	2,886	4,884	342	
23-Jul	300		1,674	1,224	2,298		
24-Jul	294		1,176	1,446	1,194		
25-Jul	246		120	0	678		
26-Jul	126				246		
27-Jul	54						
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	60,018	59,508	358,752	241,086	186,120	95,970	536,154

Appendix A. 2. Igushik River historical daily escapement, 1958-1999.

Date	1979	1980	1981	1982	1983	1984	1985
19-Jun							
20-Jun		0					
21-Jun	324	0	1,416				
22-Jun	1,068	0	1,716				
23-Jun	912	2,352	1,578	0		6	
24-Jun	1,596	1,020	1,908	0	834	258	
25-Jun	1,752	2,610	3,642	0	3,312	2,490	
26-Jun	5,352	4,650	2,550	0	6,024	7,356	
27-Jun	18,816	7,530	702	0	5,682	7,152	30
28-Jun	27,600	3,954	1,302	12,858	7,926	9,516	42
29-Jun	30,456	2,400	600	0	5,160	7,356	1,002
30-Jun	29,706	3,666	1,050	2,718	8,226	7,986	3,912
01-Jul	27,678	3,036	2,562	34,626	6,642	5,118	2,262
02-Jul	64,020	21,276	8,304	5,448	6,120	5,982	3,594
03-Jul	88,686	58,140	3,270	34,518	6,792	6,060	14,034
04-Jul	63,852	104,232	5,406	40,380	8,040	6,438	16,092
05-Jul	72,126	113,652	7,680	56,370	10,632	7,740	14,454
06-Jul	56,952	120,234	15,762	63,426	11,916	9,960	12,336
07-Jul	46,140	156,936	21,720	37,752	11,616	8,130	10,614
08-Jul	60,294	148,842	27,768	27,960	12,510	9,774	24,120
09-Jul	53,148	192,924	39,990	16,014	9,288	9,084	25,488
10-Jul	40,116	143,658	45,678	32,310	10,824	6,750	26,142
11-Jul	25,050	121,380	41,226	13,386	6,252	6,486	17,964
12-Jul	23,442	122,208	36,918	9,420	3,738	6,372	9,390
13-Jul	20,742	138,336	58,116	5,514	2,514	6,600	8,880
14-Jul	12,522	142,884	55,422	4,098	1,452	7,020	3,312
15-Jul	15,192	104,394	47,340	5,520	4,944	8,364	5,682
16-Jul	12,090	101,076	42,912	5,232	7,680	6,438	3,018
17-Jul	7,986	56,778	33,120	3,870	3,612	3,618	3,474
18-Jul	5,598	38,526	23,238	4,830	4,302	4,878	2,946
19-Jul	5,286	29,064	19,140	3,390	2,460	4,788	1,872
20-Jul	3,882	19,380	12,546	2,418	2,346	3,168	1,266
21-Jul	4,116	11,220	11,088	1,386	2,982	2,730	372
22-Jul	4,686	6,192	8,190	324	1,746	2,400	120
23-Jul	7,914	4,308	3,876		1,878	1,542	
24-Jul	5,760	672	3,408		1,314	1,272	
25-Jul	5,472				1,176	1,062	
26-Jul	7,218				480	486	
27-Jul	2,010					492	
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	859,560	1,987,530	591,144	423,768	180,420	184,872	212,418

Appendix A. 2. Igushik River historical daily escapement, 1958-1999.

Date	1986	1987	1988	1989	1990	1991	1992
19-Jun							
20-Jun	0						
21-Jun	0						6
22-Jun	0					0	540
23-Jun	0		600		714	0	1,110
24-Jun	0		1,452		942	54	5,982
25-Jun	0		2,832		636	0	3,594
26-Jun	0		4,194		2,478	4,602	1,392
27-Jun	0	1,572	6,114	5,982	4,290	26,238	1,422
28-Jun	0	2,070	9,048	17,022	3,684	51,342	3,210
29-Jun	0	6,510	6,072	11,112	2,580	29,220	11,946
30-Jun	78	3,366	4,224	7,140	2,196	22,680	11,232
01-Jul	2,166	6,498	4,758	6,630	3,072	20,724	13,530
02-Jul	1,968	9,048	11,670	12,462	6,726	15,702	18,186
03-Jul	612	7,212	9,072	25,476	10,572	18,594	18,312
04-Jul	1,854	12,768	9,018	31,014	32,418	48,234	7,872
05-Jul	7,134	9,564	8,844	27,066	42,786	105,132	2,448
06-Jul	23,484	3,378	11,208	16,998	37,356	115,884	7,446
07-Jul	24,432	5,112	10,266	40,176	28,176	60,162	9,258
08-Jul	8,856	7,914	9,888	48,384	39,876	51,186	18,294
09-Jul	19,896	4,794	9,930	47,196	31,944	33,810	23,526
10-Jul	44,622	8,190	8,700	31,920	31,536	18,174	13,608
11-Jul	29,634	4,872	7,356	22,320	13,140	16,218	29,916
12-Jul	18,036	3,642	6,084	12,732	16,434	14,220	21,708
13-Jul	13,800	4,746	4,230	17,232	13,764	11,148	26,052
14-Jul	8,802	5,604	7,596	18,618	7,416	10,062	13,860
15-Jul	9,888	4,212	7,242	16,584	6,222	11,568	11,472
16-Jul	18,870	3,768	3,456	15,894	7,620	10,308	7,458
17-Jul	14,382	3,840	2,922	7,854	4,200	13,488	6,264
18-Jul	13,590	9,012	1,872	4,650	4,170	12,564	4,236
19-Jul	11,562	10,494	996	5,376	3,936	13,962	3,204
20-Jul	8,556	8,832	762	4,176	2,910	9,348	5,382
21-Jul	8,088	7,824		2,274	2,244	5,916	1,842
22-Jul	6,612	4,878		2,352	1,284	2,130	612
23-Jul	4,644	5,328		1,818	474	3,708	
24-Jul	4,212	2,982		1,152		(252)	
25-Jul	3,042	978					
26-Jul		228					
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	308,820	169,236	170,406	461,610	365,796	756,126	304,920

Appendix A. 2. Igushik River historical daily escapement, 1958-1999.

Date	1993	1994	1995	1996	1997	1998	1999
19-Jun							
20-Jun							
21-Jun							
22-Jun	120	54					
23-Jun	3,102	234	306		474		
24-Jun	3,198	126	558	3,546	804		
25-Jun	5,208	456	2,322	5,166	972		6
26-Jun	3,990	918	6,060	14,952	738		0
27-Jun	8,844	906	27,354	12,390	1,872		0
28-Jun	13,848	2,700	29,484	20,934	2,364	6	0
29-Jun	22,566	2,994	26,922	11,046	2,640	378	0
30-Jun	24,144	1,734	41,712	4,860	1,626	978	2,958
01-Jul	24,360	1,836	38,592	4,038	1,044	924	4,632
02-Jul	9,720	4,782	51,600	2,724	1,074	780	23,532
03-Jul	22,728	3,042	24,972	3,252	1,062	2,268	30,342
04-Jul	20,736	12,912	12,048	4,206	2,094	14,790	34,410
05-Jul	32,478	15,552	9,804	4,566	2,694	32,322	49,140
06-Jul	49,188	11,310	6,960	7,632	4,638	34,380	42,168
07-Jul	36,762	13,686	6,594	7,884	2,622	16,536	45,486
08-Jul	19,626	6,198	12,942	11,916	3,132	14,034	39,072
09-Jul	11,556	8,484	24,882	13,770	5,220	18,834	41,340
10-Jul	6,672	21,198	25,998	17,214	6,954	19,362	23,874
11-Jul	4,548	51,924	13,758	23,694	8,706	7,164	12,258
12-Jul	6,966	45,864	16,266	32,808	8,346	6,126	8,124
13-Jul	14,592	39,528	13,320	40,044	7,158	7,428	8,694
14-Jul	14,634	38,232	11,022	32,082	6,786	10,062	7,536
15-Jul	13,470	16,776	9,282	21,498	7,428	7,590	5,850
16-Jul	8,970	8,688	7,026	21,636	8,622	5,322	10,968
17-Jul	6,486	13,788	7,668	11,088	8,532	4,362	13,176
18-Jul	5,358	22,794	7,566	9,876	8,526	2,856	14,490
19-Jul	4,656	22,650	9,564	8,646	6,114	3,966	8,796
20-Jul	3,684	18,198	10,140	8,934	4,356	2,322	6,036
21-Jul	2,256	11,394	10,158	7,800	3,732	1,284	6,600
22-Jul	1,098	10,260	8,502	7,566	2,598	1,830	6,048
23-Jul		7,422		8,436	2,256		
24-Jul		7,194		10,104	2,520		
25-Jul		10,242		6,438			
26-Jul		7,194					
27-Jul		4,650					
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	405,564	445,920	473,382	400,746	127,704	215,904	445,536

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Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1955	1956	1957	1958	1959	1960
19-Jun						
20-Jun						
21-Jun					308	402
22-Jun					623	135
23-Jun	120	8		0	307	312
24-Jun	256	38		0	99	90
25-Jun	509	32		0	212	
26-Jun	166	30	7,337	24	941	18
27-Jun	211	88	4,987	29	416	186
28-Jun	38	263	2,922	58	1,133	2,322
29-Jun	90	229	9,305	515	440	1,776
30-Jun	112	343	46,825	582	1,098	1,998
01-Jul	186	311	51,797	174	588	9,747
02-Jul	148	311	62,332	1,485	384	155,394
03-Jul	102	373	82,789	960	1,152	221,586
04-Jul	151	11,280	60,394	153	7,872	361,572
05-Jul	3,426	10,256	70,371	129	49,612	384,012
06-Jul	24,364	63,065	48,245	48	51,288	359,946
07-Jul	9,125	75,851	45,703	29,328	48,780	586,728
08-Jul	657	134,163	83,275	161,109	30,758	644,058
09-Jul	893	221,055	56,435	148,760	12,524	702,966
10-Jul	918	268,179	147,794	44,945	19,097	727,644
11-Jul	12,766	268,048	283,029	24,802	32,627	1,075,212
12-Jul	11,351	375,393	461,443	3,575	21,285	1,332,329
13-Jul	6,937	498,944	461,961	2,241	52,818	1,046,130
14-Jul	5,458	583,882	371,154	3,966	88,226	972,978
15-Jul	21,578	694,874	147,430	43,458	90,994	943,860
16-Jul	73,304	923,007	88,426	47,559	55,343	1,001,322
17-Jul	31,822	1,053,583	56,012	5,946	23,398	1,116,582
18-Jul	13,398	910,574	30,330	1,530	16,093	1,262,790
19-Jul	5,726	711,050	49,258	879	17,357	928,770
20-Jul	4,146	650,430	72,705	1,017	13,225	529,158
21-Jul	4,781	606,643	37,966	2,673	9,140	115,725
22-Jul	4,537	440,420	26,820	834	5,637	39,345
23-Jul	3,972	288,795	23,152	2,130	5,631	36,324
24-Jul	2,245	212,571	25,612	2,274	3,801	22,457
25-Jul	2,187	154,609	14,537	999	1,514	9,678
26-Jul	1,073	98,495	34,409	357	2,119	8,808
27-Jul	962	66,923		543	2,189	
28-Jul	785	37,516		938	2,592	
29-Jul	797	25,100		384	1,800	
30-Jul	545	20,353		381	390	
31-Jul	409	15,999				
01-Aug	213	14,558				
02-Aug	82	5,676				
Total	250,546	9,443,318	2,964,755	534,785	673,811	14,602,360

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1961	1962	1963	1964	1965	1966	1967
19-Jun							
20-Jun							
21-Jun							
22-Jun	120	584					
23-Jun	120	486	72	0	12	0	1,122
24-Jun	120	708	66	18	300	0	18,054
25-Jun	264	276	66	132	7,518	0	6,246
26-Jun	3,378	780	54	300	39,942	0	30,858
27-Jun	51,192	5,922	30	186	66,984	12	115,554
28-Jun	88,884	5,670	30	522	97,006	0	54,798
29-Jun	134,934	3,366	702	348	127,028	12	84,432
30-Jun	122,316	5,724	5,628	468	156,540	12,852	281,640
01-Jul	78,510	29,868	10,368	1,074	247,332	14,298	349,254
02-Jul	33,804	153,798	5,598	1,554	467,154	38,784	293,616
03-Jul	270,726	123,996	7,986	1,848	589,908	17,676	111,864
04-Jul	232,488	43,758	5,100	1,020	373,602	23,748	188,592
05-Jul	375,048	91,842	5,082	624	433,794	158,544	211,240
06-Jul	470,478	242,700	18,606	8,406	723,006	266,568	233,832
07-Jul	420,846	509,478	40,944	31,482	1,180,272	439,866	210,252
08-Jul	261,840	413,238	36,000	64,752	1,588,650	506,844	202,440
09-Jul	146,634	537,216	31,434	78,852	2,194,200	466,758	216,222
10-Jul	72,684	329,652	7,032	44,460	2,265,330	381,504	136,422
11-Jul	169,254	50,370	24,246	56,898	1,737,480	318,840	35,868
12-Jul	128,100	2,424	32,970	51,444	1,736,040	400,038	15,276
13-Jul	200,028	2,526	25,608	176,682	1,551,240	259,692	85,314
14-Jul	161,700	4,014	22,188	126,720	1,185,060	126,936	142,200
15-Jul	125,376	2,538	12,018	71,004	852,420	65,256	34,302
16-Jul	48,552	2,904	7,632	55,392	808,098	42,774	34,326
17-Jul	14,634	5,514	7,776	28,410	747,762	29,184	30,198
18-Jul	24,546	3,978	9,288	12,528	1,266,480	32,298	29,214
19-Jul	26,826	1,392	5,358	17,232	1,180,500	44,292	23,652
20-Jul	10,848	360	5,598	17,160	930,420	37,434	9,120
21-Jul	5,166	684	3,768	19,896	726,354	28,548	9,510
22-Jul	8,628	282	2,202	15,852	464,454	19,890	5,844
23-Jul	6,393	714	960	17,550	190,260	8,658	3,498
24-Jul	4,038	942	1,442	28,434	117,954	4,344	2,184
25-Jul	2,760	570	1,146	12,762	101,352	3,450	2,700
26-Jul	2,508	870	678	6,408	72,078	2,250	2,172
27-Jul	960	1,140	528	1,902	44,274	1,410	2,148
28-Jul	642	396	228	1,272	25,446	1,602	1,344
29-Jul	264	204	84	1,182	14,298	822	354
30-Jul	180	0	42	1,086	5,388	600	234
31-Jul	60	0	12	756	4,644	400	54
01-Aug							
02-Aug							
Total	3,705,849	2,580,884	338,570	956,616	24,320,580	3,756,184	3,215,950

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1968	1969	1970	1971	1972	1973
19-Jun						
20-Jun						
21-Jun						
22-Jun						
23-Jun	72	66	492	0	0	0
24-Jun	6	24	4,248	0	0	144
25-Jun	24	180	2,970	0	0	108
26-Jun	804	228	2,730	0	0	510
27-Jun	1,440	78	6,084	0	12	456
28-Jun	3,954	96	45,168	0	0	582
29-Jun	115,434	174	181,728	0	0	1,014
30-Jun	155,484	54,174	487,092	0	96	804
01-Jul	164,712	185,544	646,140	2,154	42	594
02-Jul	102,420	228,942	622,800	5,418	336	2,616
03-Jul	125,490	302,562	797,340	3,828	1,080	3,918
04-Jul	133,620	416,634	1,104,780	4,338	672	4,794
05-Jul	240,984	563,040	1,176,900	1,614	198	2,094
06-Jul	289,590	727,032	1,408,290	1,368	204	2,874
07-Jul	286,182	847,122	935,490	17,964	79,356	6,258
08-Jul	254,088	950,016	904,320	103,476	265,284	21,666
09-Jul	141,048	868,470	990,420	151,626	186,276	63,402
10-Jul	76,686	797,400	934,500	200,874	115,608	57,552
11-Jul	141,984	673,680	1,242,642	283,590	170,202	25,962
12-Jul	149,796	395,304	580,110	265,050	94,626	6,252
13-Jul	92,940	361,374	541,116	147,906	39,204	3,198
14-Jul	26,544	295,086	404,100	88,950	22,782	2,184
15-Jul	15,516	268,878	257,580	199,674	17,796	1,044
16-Jul	13,086	163,350	137,004	200,712	7,212	1,410
17-Jul	7,470	116,124	39,972	221,034	2,514	2,562
18-Jul	5,370	62,412	42,924	157,796	3,312	768
19-Jul	4,032	31,050	102,120	94,558	1,284	10,116
20-Jul	1,362	21,984	85,680	31,320	696	2,976
21-Jul	1,494	21,828	66,606	30,516	276	552
22-Jul	1,236	15,228	55,668	28,000	252	126
23-Jul	960	10,446	35,112	25,000	288	18
24-Jul	918	6,480	16,698	22,000	354	0
25-Jul	564	3,150	11,178	20,000	0	0
26-Jul	522	1,926	9,426	18,000	0	0
27-Jul	294	1,614	5,166	15,000	0	0
28-Jul	306	906	3,966	12,000	0	0
29-Jul		492	10,866	10,500	0	0
30-Jul		876	10,428	9,000	0	0
31-Jul		204	6,492	8,000	0	0
01-Aug						
02-Aug						
Total	2,556,432	8,394,174	13,916,346	2,381,266	1,009,962	226,554

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1974	1975	1976	1977	1978	1979
19-Jun						
20-Jun						
21-Jun						
22-Jun						
23-Jun	1,008	126	0	528	312	396
24-Jun	1,164	192	0	2,484	8,652	222
25-Jun	1,734	1,212	468	2,940	29,118	356,430
26-Jun	5,694	1,500	780	5,292	22,356	686,868
27-Jun	5,160	960	318	11,226	6,048	850,170
28-Jun	17,178	312	204	5,058	2,166	887,382
29-Jun	47,028	216	360	7,818	101,766	1,015,074
30-Jun	208,056	31,362	240	66,672	250,020	975,168
01-Jul	258,618	438,648	180	131,484	268,620	557,016
02-Jul	288,462	439,140	1,662	86,820	130,782	585,012
03-Jul	320,760	367,950	12,174	103,392	43,548	925,692
04-Jul	311,268	566,172	104,652	129,702	15,420	640,218
05-Jul	366,936	639,804	191,208	145,374	31,872	492,762
06-Jul	362,790	755,232	323,244	150,180	285,312	486,090
07-Jul	330,510	849,882	251,628	87,558	611,586	667,410
08-Jul	387,078	882,666	64,356	33,876	702,672	573,660
09-Jul	327,510	889,614	25,812	27,168	456,054	446,460
10-Jul	398,334	961,260	74,736	15,006	517,146	294,828
11-Jul	296,058	850,440	204,390	9,618	388,590	220,122
12-Jul	208,356	782,352	268,680	50,448	81,756	107,712
13-Jul	106,200	661,164	214,416	50,952	34,674	90,576
14-Jul	83,928	610,632	118,704	70,740	74,112	68,160
15-Jul	39,798	640,572	34,566	76,380	22,788	76,992
16-Jul	16,650	627,066	18,378	25,704	10,170	57,696
17-Jul	11,112	527,058	9,432	11,826	3,948	48,888
18-Jul	11,364	322,578	10,410	9,582	4,332	38,922
19-Jul	5,142	304,776	12,684	7,740	13,236	25,614
20-Jul	3,312	254,664	7,464	6,264	15,606	23,220
21-Jul	3,516	214,392	8,340	3,798	10,236	10,050
22-Jul	3,600	171,144	3,726	2,664	6,228	6,468
23-Jul	1,428	179,670	2,070	1,764	0	1,350
24-Jul	1,764	77,568	0	1,044	0	0
25-Jul	900	46,788	0	0	0	0
26-Jul	516	23,196	0	0	0	0
27-Jul	600	11,184	0	0	0	0
28-Jul	312	6,450	0	0	0	0
29-Jul	0	2,412	0	0	0	0
30-Jul	0	0	0	0	0	0
31-Jul	0	0	0	0	0	0
01-Aug						
02-Aug						
Total	4,433,844	13,140,354	1,965,282	1,341,102	4,149,126	11,216,628

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1980	1981	1982	1983	1984	1985
19-Jun		108		0		
20-Jun		366		66	168	
21-Jun		228		150	42	
22-Jun	4,446	4,020	30	174	6	
23-Jun	1,644	16,950	12	54	258	30
24-Jun	840	7,632	18	48	426	6
25-Jun	480	3,696	0	6	16,578	54
26-Jun	450	1,572	6	6	68,946	24
27-Jun	148,122	582	0	2,628	34,206	78
28-Jun	825,480	1,050	12	139,062	12,504	113,040
29-Jun	1,090,650	32,238	18	378,324	671,250	248,586
30-Jun	1,006,020	47,814	18	422,922	1,017,054	268,590
01-Jul	1,355,130	140,502	8,460	422,352	778,200	348,390
02-Jul	1,520,382	181,512	6,306	316,806	516,378	237,174
03-Jul	1,360,860	38,802	1,398	96,084	514,080	120,714
04-Jul	1,847,400	58,566	9,066	86,694	689,580	263,520
05-Jul	1,567,500	299,322	5,658	99,576	793,596	305,760
06-Jul	1,536,300	191,088	14,982	46,890	854,580	422,682
07-Jul	1,334,820	36,396	92,112	42,204	819,480	408,498
08-Jul	1,413,720	30,576	282,342	155,844	794,136	398,586
09-Jul	1,310,760	120,684	130,500	349,170	855,420	696,174
10-Jul	1,105,380	286,428	47,262	95,220	555,960	792,150
11-Jul	1,078,140	175,344	32,286	31,884	229,194	702,282
12-Jul	906,780	28,914	49,086	48,990	136,014	473,142
13-Jul	852,780	19,116	17,220	54,708	390,366	297,138
14-Jul	616,680	7,470	9,378	63,336	283,446	298,524
15-Jul	436,278	3,192	6,438	341,754	79,284	220,332
16-Jul	311,628	9,606	96,768	222,414	60,756	110,778
17-Jul	230,676	5,178	112,752	29,346	98,478	41,952
18-Jul	183,294	1,410	59,202	39,834	89,448	19,044
19-Jul	161,976	3,990	93,876	52,686	70,332	7,308
20-Jul	95,328	0	38,994	19,266	24,918	2,496
21-Jul	52,782	0	2,394	6,138	11,880	2,058
22-Jul	98,148	0	1,734	4,170	8,508	64,830
23-Jul	36,660	0	1,248	1,176	8,712	256,434
24-Jul	13,734	0	3,576	0	5,202	66,270
25-Jul	0	0	5,916	0	1,260	10,608
26-Jul	0	0	4,392	0	0	6,888
27-Jul	0	0	960	0	0	2,742
28-Jul	0	0	0	0	0	3,090
29-Jul	0	0	0	0	0	942
30-Jul	0	0	0	0	0	0
31-Jul	0	0	0	0	0	0
01-Aug						
02-Aug						
Total	22,505,268	1,754,352	1,134,420	3,569,982	10,490,646	7,210,914

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1986	1987	1988	1989	1990	1991	1992
19-Jun							
20-Jun							
21-Jun							
22-Jun						42	
23-Jun	0	0				30	450
24-Jun	0	0			0	0	768
25-Jun	0	0	1,068	57,516	942	60	1,260
26-Jun	0	0	3,378	240,756	1,110	594	7,080
27-Jun	0	0	71,958	226,830	1,350	2,844	6,966
28-Jun	0	0	188,070	128,028	2,232	45,960	64,962
29-Jun	0	0	48,396	239,034	2,694	75,210	173,922
30-Jun	0	36	14,730	616,362	31,104	152,598	191,496
01-Jul	48	30,138	36,204	543,372	6,228	310,830	188,556
02-Jul	480	506,616	414,204	514,170	173,064	312,918	119,406
03-Jul	7,272	581,382	414,504	721,308	606,654	354,504	43,926
04-Jul	66,756	428,826	405,258	1,090,380	586,980	325,824	294,666
05-Jul	137,814	155,970	303,438	1,040,100	461,508	343,572	569,814
06-Jul	56,106	78,786	178,062	529,164	525,504	215,718	581,130
07-Jul	9,210	85,398	109,842	663,636	502,110	66,822	443,604
08-Jul	2,244	769,230	42,528	571,368	607,410	69,090	191,712
09-Jul	30,642	1,022,298	40,224	336,084	552,180	77,946	79,872
10-Jul	131,418	867,432	117,084	151,398	630,690	278,598	25,212
11-Jul	97,446	610,434	385,602	38,898	389,130	446,826	190,398
12-Jul	140,814	267,528	698,280	46,986	307,350	379,860	486,966
13-Jul	174,306	250,356	279,762	50,640	414,600	179,508	404,100
14-Jul	132,540	118,890	87,486	53,886	405,150	83,712	263,544
15-Jul	92,598	105,150	107,856	54,270	210,108	97,656	107,964
16-Jul	22,728	67,524	41,706	146,046	91,980	86,838	78,714
17-Jul	7,428	24,576	30,636	70,032	93,360	89,874	61,158
18-Jul	5,652	14,592	25,224	33,654	70,434	64,428	47,760
19-Jul	4,000	15,072	11,742	42,966	58,692	53,070	37,566
20-Jul	3,000	12,492	4,296	40,608	48,510	30,270	23,856
21-Jul	8,000	19,122	3,078	27,522	46,056	24,432	22,806
22-Jul	24,000	22,950	600	14,370	48,876	26,520	8,556
23-Jul	15,000	8,508	0	7,692	38,748	26,634	5,262
24-Jul	5,000	2,580	0	7,068	26,706		2,412
25-Jul	3,000		0	10,332	28,560		
26-Jul	1,000		0	5,076			
27-Jul	1,000		0				
28-Jul	0		0				
29-Jul	0		0				
30-Jul	0		0				
31-Jul	0		0				
01-Aug							
02-Aug							
Total	1,179,502	6,065,886	4,065,216	8,319,552	6,970,020	4,222,788	4,725,864

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1993	1994	1995	1996	1997	1998
19-Jun						
20-Jun						
21-Jun				0		
22-Jun	13,350			0		
23-Jun	11,016	42	0	0		
24-Jun	9,828	24	0	42	2,676	60
25-Jun	17,148	84	60	4,062	3,624	24
26-Jun	69,912	738	41,346	21,174	8,718	936
27-Jun	195,312	6,744	319,944	11,310	26,742	2,028
28-Jun	242,394	16,254	362,952	3,366	18,144	2,694
29-Jun	287,724	762	217,164	1,002	6,732	10,344
30-Jun	84,936	306	172,302	774	6,084	10,044
01-Jul	82,140	504	496,818	5,574	3,174	5,628
02-Jul	67,596	3,630	727,884	42,894	7,026	354
03-Jul	101,010	224,208	459,504	133,902	33,054	52,236
04-Jul	124,632	1,295,892	307,452	93,732	42,012	148,554
05-Jul	371,016	1,176,840	241,008	43,410	48,054	184,488
06-Jul	694,122	790,896	637,032	23,724	93,486	179,868
07-Jul	360,738	754,686	954,258	35,016	139,878	155,388
08-Jul	198,834	859,236	992,880	48,390	197,742	80,016
09-Jul	169,782	689,646	1,090,020	99,852	159,678	147,258
10-Jul	162,930	652,626	663,348	100,518	152,742	385,620
11-Jul	138,030	597,420	322,104	100,266	103,224	429,936
12-Jul	171,300	215,106	163,656	90,954	87,138	275,148
13-Jul	177,228	62,394	260,928	175,452	60,432	110,676
14-Jul	67,488	52,074	227,700	124,392	90,690	57,150
15-Jul	45,870	113,484	220,332	77,856	57,654	30,894
16-Jul	29,250	44,664	139,254	72,318	32,586	10,602
17-Jul	27,078	90,924	113,472	22,134	29,706	4,836
18-Jul	37,260	220,458	116,496	20,640	23,508	5,802
19-Jul	28,152	247,620	264,048	43,956	20,298	3,204
20-Jul	10,302	69,474	191,010	25,728	12,804	1,512
21-Jul	11,334	24,594	85,392	13,344	14,178	774
22-Jul	8,082	72,216	87,276	9,306	10,872	
23-Jul	5,178	72,390	43,074	5,490	11,076	
24-Jul	3,084		35,502			
25-Jul	1,110		39,882			
26-Jul			44,622			
27-Jul						
28-Jul						
29-Jul						
30-Jul						
31-Jul						
01-Aug						
02-Aug						
Total	4,025,166	8,355,936	10,038,720	1,450,578	1,503,732	2,296,074

Appendix A. 3. Kvichak River historical daily escapement, 1955-1999.

Date	1999
19-Jun	
20-Jun	
21-Jun	
22-Jun	
23-Jun	
24-Jun	
25-Jun	54
26-Jun	36
27-Jun	90
28-Jun	24
29-Jun	234
30-Jun	16,962
01-Jul	87,450
02-Jul	232,242
03-Jul	411,228
04-Jul	338,088
05-Jul	437,124
06-Jul	304,272
07-Jul	428,358
08-Jul	532,554
09-Jul	403,932
10-Jul	395,958
11-Jul	215,850
12-Jul	228,000
13-Jul	299,562
14-Jul	317,820
15-Jul	298,842
16-Jul	162,348
17-Jul	310,638
18-Jul	428,550
19-Jul	189,006
20-Jul	70,278
21-Jul	41,988
22-Jul	24,882
23-Jul	20,544
24-Jul	
25-Jul	
26-Jul	
27-Jul	
28-Jul	
29-Jul	
30-Jul	
31-Jul	
01-Aug	
02-Aug	
Total	6,196,914

Appendix A. 4. Naknek River historical daily escapement, 1958-1999.

Date	1958	1959	1960	1961	1962	1963	1964
19-Jun							
20-Jun							
21-Jun		18					
22-Jun		858					42
23-Jun		156					234
24-Jun		2,688				36	1,602
25-Jun		1,182			6	60	1,440
26-Jun		594		11,166	7,122	126	3,036
27-Jun	174	7,437		13,044	1,578	1,512	10,794
28-Jun	18	7,113	0	4,044	1,434	24,786	4,710
29-Jun	474	429	582	2,028	10,974	61,968	55,734
30-Jun	660	7,542	8,376	1,296	74,286	10,734	33,828
01-Jul	258	22,875	89,502	1,218	20,214	93,804	19,788
02-Jul	3,108	68,895	31,890	1,836	10,956	21,306	4,908
03-Jul	4,296	177,099	11,322	99,042	20,112	57,864	2,088
04-Jul	9,456	166,311	20,058	12,258	21,666	43,500	21,222
05-Jul	8,352	177,054	9,642	17,034	293,712	206,178	212,724
06-Jul	59,016	132,645	147,228	4,266	128,514	97,116	543,144
07-Jul	56,676	51,144	95,916	1,674	115,938	52,140	153,768
08-Jul	36,690	80,364	62,976	5,472	6,024	12,780	44,808
09-Jul	20,244	119,436	90,828	5,592	2,412	34,572	22,542
10-Jul	11,550	43,386	36,144	13,668	1,116	50,814	73,128
11-Jul	5,364	103,233	16,828	34,302	1,182	50,922	22,614
12-Jul	3,306	460,839	19,698	52,218	1,194	15,246	18,756
13-Jul	4,032	284,553	20,904	27,228	2,142	11,706	21786
14-Jul	23,718	112,880	11,568	10,260	954	24,192	26274
15-Jul	8,592	32,440	39,972	3,000	66	9,642	9,744
16-Jul	2,448	27,036	36,444	5,556	792	9,762	8,070
17-Jul	2,316	47,244	10,830	8,664	372	2,592	10,980
18-Jul	2,136	26,136	14,088	5,922	216	3,060	4,188
19-Jul	2,430	19,132	9,432	684	18	900	5,538
20-Jul	2,442	6,396	6,810	552	42	654	4,590
21-Jul	2,610	6,018	6,660	984	24	2,334	3,174
22-Jul	1,908	6,256	4,092	552		2,178	1,596
23-Jul	1,488	7,804	3,432	336		1,440	648
24-Jul	1,566	6,684	2,928	2,748		540	792
25-Jul	882	5,824	2,220	1,674		228	1,002
26-Jul	774	3,432	2,622	462		234	312
27-Jul	354	1,860	2,844	324		210	
28-Jul	318	1,988	2,496	438		90	
29-Jul	270	1,112	2,535	324		102	
30-Jul	36	2,104	2,901	204		30	
31-Jul	108	1,612	1,356	429			
01-Aug	48		1,194	354			
02-Aug	0		822	84			
03-Aug			1,005	141			
04-Aug			756				
05-Aug			480				
Total	280,076	2,233,766	830,341	351,078	723,066	905,358	1,349,604

Appendix A. 4. Naknek River historical daily escapement, 1958-1999.

Date	1965	1966	1967	1968	1969	1970	1971
19-Jun							
20-Jun							
21-Jun	0	222	1686	312			
22-Jun	12	66	7314	300			
23-Jun	36	60	5,364	72	0		
24-Jun	138	114	4,986	4,872	0		60
25-Jun	402	336	27,534	12,306	0	0	366
26-Jun	78	222	18,486	3,690	744	390	138
27-Jun	360	1,920	17,358	21,294	15,666	858	96
28-Jun	3,120	3,156	60,384	120,282	87,078	30,582	60
29-Jun	1,140	5,190	120,750	21,702	132,804	45,606	156
30-Jun	2,280	16,200	90,252	81,774	182,664	20,532	2,010
01-Jul	10,566	28,492	40,584	135,936	216,054	21,444	1,134
02-Jul	9,276	10,189	32,172	105,864	202,662	58,608	6,300
03-Jul	16,824	66,552	52,884	92,148	185,736	62,352	2,520
04-Jul	32,022	42,672	40,224	139,434	138,696	59,226	1,764
05-Jul	74,256	209,278	55,626	145,884	34,914	56,334	18,108
06-Jul	184,332	218,130	30,234	36,900	9,030	71,406	25,164
07-Jul	44,346	228,660	31,896	12,270	11,058	106,374	82,854
08-Jul	31,188	86,328	26,346	8,502	12,690	50,160	118,284
09-Jul	39,120	30,792	15,240	15,528	20,868	37,588	223,008
10-Jul	41,802	8,760	8,412	16,218	18,594	17,898	201,522
11-Jul	12,732	23,712	9,750	9,168	15,582	19,338	116,988
12-Jul	25,836	11,808	21,198	8,922	13,752	28,404	54,894
13-Jul	33,426	3,894	9,588	5,610	7,068	21,582	21,024
14-Jul	19,638	3,576	5,496	4,332	7,020	5,004	18,054
15-Jul	33,024	4,278	5,730	4,644	2,754	1,506	14,088
16-Jul	45,684	2,688	5,304	2,754	1,734	2,976	4,608
17-Jul	12,186	4,638	6,144	1,278	1,206	4,230	4,908
18-Jul	11,268	3,444	1,938	1,806	1,578	3,696	402
19-Jul	12,390	696	1,020	1,800	954	1,830	1,824
20-Jul	4,464	168	720	1,116	1,212	1,326	792
21-Jul	3,366	180	582	1,224	1,332	516	2,094
22-Jul	2,340		354	912	1,728	180	4,242
23-Jul	3,060			1,026	1,518	246	1,902
24-Jul	1,170			918	678	348	1,218
25-Jul	1,896			648	1,128	318	1,374
26-Jul	1,092			624	840	348	1,014
27-Jul	720			120	492	552	768
28-Jul	396			150	642	390	1,248
29-Jul	660				462	282	558
30-Jul	606				264	72	210
31-Jul	546						
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	719,763	1,016,421	755,556	1,022,340	1,331,202	732,502	935,754

Appendix A. 4. Naknek River historical daily escapement, 1958-1999.

Date	1972	1973	1974	1975	1976	1977	1978
19-Jun							
20-Jun							
21-Jun						120	
22-Jun						1218	
23-Jun		0	786	36		3,114	0
24-Jun		60	996	48	0	324	252
25-Jun		1,452	22,644	12	0	18,780	90
26-Jun		816	10,350	78	396	51,606	102
27-Jun	0	8,694	19,176	36	558	40,116	1,194
28-Jun	882	10,980	44,658	6	4,212	6,216	28,758
29-Jun	6,180	2,874	75,942	3,132	9,660	247,314	28,920
30-Jun	45,240	2,526	143,550	150,402	354	150,078	42,678
01-Jul	6,270	11,466	128,664	133,494	43,074	25,884	13,002
02-Jul	5,370	4,392	144,912	48,462	131,292	34,698	4,800
03-Jul	16,854	10,002	117,972	41,268	208,014	150,516	10,728
04-Jul	70,824	13,656	189,186	119,634	74,538	143,160	55,392
05-Jul	109,158	28,476	175,410	473,598	133,884	8,988	147,426
06-Jul	95,028	31,800	62,796	471,306	60,402	4,506	160,848
07-Jul	80,370	89,928	21,426	168,624	28,386	4,548	85,320
08-Jul	35,064	47,208	26,484	127,542	56,646	8,910	75,930
09-Jul	28,776	34,788	27,426	28,386	181,470	26,226	21,516
10-Jul	27,732	1,200	7,728	15,060	235,926	61,716	30,210
11-Jul	15,606	4,152	4,314	98,124	58,632	63,354	10,938
12-Jul	13,386	4,812	3,534	76,026	10,236	16,554	41,064
13-Jul	9,864	13,578	3,360	18,870	7,740	5,574	20,082
14-Jul	4,248	18,174	2,232	11,244	10,224	4,362	5,970
15-Jul	2,490	4,536	1,842	5,496	7,770	2,676	2,658
16-Jul	4,434	888	1,452	12,936	10,656	3,012	8,154
17-Jul	4,176	3,756	1,020	7,080	9,150	2,160	9,912
18-Jul	1,656	3,798	1,404	6,366	13,728		2,880
19-Jul	738	1,002	900	1,740	10,920		2,880
20-Jul	1,008	630	324	2,736	6,474		966
21-Jul	492	462	402	2,730	2,634		708
22-Jul	378	372	168	1,452	2,412		
23-Jul	294	198		624	1,362		
24-Jul				138			
25-Jul							
26-Jul							
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	586,518	356,676	1,241,058	2,026,686	1,320,750	1,085,730	813,378

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Appendix A. 4. Naknek River historical daily escapement, 1958-1999.

Date	1979	1980	1981	1982	1983	1984	1985
19-Jun							
20-Jun							
21-Jun	0		1,266	744		240	
22-Jun	48		10,824	120		9,120	
23-Jun	138		9,048	0	384	132	264
24-Jun	16,338		8,742	6	228	7,962	390
25-Jun	133,716	276	3,624	24	168	8,772	78
26-Jun	98,424	20,940	4,122	18	24,042	18,990	6
27-Jun	106,122	180,084	28,674	798	70,614	22,866	189,054
28-Jun	133,692	243,312	44,184	4,800	76,950	131,664	226,116
29-Jun	45,894	438,456	65,946	43,440	86,148	158,778	60,624
30-Jun	14,550	434,958	290,700	246,114	55,164	46,884	68,364
01-Jul	55,596	259,194	15,840	33,618	40,680	46,248	54,180
02-Jul	89,046	120,228	103,932	7,038	23,568	51,438	65,484
03-Jul	17,088	226,668	275,280	30,840	33,582	105,684	43,230
04-Jul	30,624	228,558	203,700	214,350	27,390	216,666	11,196
05-Jul	33,972	17,064	25,458	117,498	27,612	138,918	64,122
06-Jul	56,202	54,876	15,894	46,746	32,784	21,612	48,180
07-Jul	40,512	110,370	13,800	50,442	66,420	38,658	192,564
08-Jul	12,330	44,784	326,970	83,070	29,202	87,714	351,798
09-Jul	6,870	21,846	291,072	74,010	33,048	14,958	153,492
10-Jul	3,648	26,532	10,620	34578	22,362	9,786	12,084
11-Jul	8,838	34,596	11,730	5,616	83,070	19,800	9,192
12-Jul	7,092	87,978	4,902	9,156	41,982	55,878	32,442
13-Jul	5,244	37,110	3,558	3,348	27,282	10,086	26,190
14-Jul	4,050	13,062	11,676	2,760	30,114	5,010	57,380
15-Jul	2,244	20,058	4,194	10,770	6,972	4,542	38,076
16-Jul	1,698	11,622	3,378	6,594	2,238	4,560	22,194
17-Jul		6,450	3,144	83,004	6,984	3,282	13,974
18-Jul		5,664	3,714	19,452	20,796	1,296	14,670
19-Jul				5,166	11,790	606	18,048
20-Jul				8,016	4,230		20,286
21-Jul				2,592	2,274		43,224
22-Jul				9,096			7,008
23-Jul				1,686			4,746
24-Jul							1,332
25-Jul							
26-Jul							
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	923,976	2,644,686	1,795,992	1,155,510	888,078	1,242,150	1,849,988

Appendix A. 4. Naknek River historical daily escapement, 1958-1999.

Date	1986	1987	1988	1989	1990	1991	1992
19-Jun							
20-Jun							
21-Jun		0					1,230
22-Jun		60		840	1,158		1,794
23-Jun	24	24	252	972	6,126	588	2,586
24-Jun	480	0	1,062	7,902	2,190	792	8,904
25-Jun	630	0	15,492	28,800	3,762	96	12,510
26-Jun	30	0	9,564	36,534	69,396	104,316	43,200
27-Jun	6	216	39,540	6,030	17,496	102,576	109140
28-Jun	906	186	8,718	66,306	27,606	113,226	8082
29-Jun	14,172	24	9,528	226,428	146,736	326,316	12612
30-Jun	1,566	30,660	67,272	68,184	146,694	504,216	49128
01-Jul	414	265,752	140,556	72,564	137,100	669,858	10476
02-Jul	379,374	59,190	47,586	195,618	285,234	517,218	69774
03-Jul	382,494	15,024	120,600	121,878	75,528	295,194	365112
04-Jul	72,048	13,980	56,448	31,716	158,478	244,176	242454
05-Jul	40,686	33,600	24,906	27,492	108,486	30,366	135642
06-Jul	16,110	121,608	14,988	47,520	174,054	8,274	41898
07-Jul	38,184	193,326	31,806	26,808	113,286	8,220	21624
08-Jul	134,964	104,520	71,262	28,584	45,426	12,172	11166
09-Jul	299,262	86,442	111,612	18,258	34,362	132,282	12138
10-Jul	332,088	9,888	134,046	5,172	58,086	73,836	57594
11-Jul	56,034	45,720	23,280	17,616	91,866	25,224	128148
12-Jul	47,430	26,682	21,666	14,292	79,524	25,398	91494
13-Jul	15,348	10,860	28,170	22,020	54,324	16,050	65136
14-Jul	13,800	7,416	21,720	14,310	34,152	39,258	56784
15-Jul	8,508	5,010	6,696	48,120	26,304	151,968	10866
16-Jul	57,415	2,328	20,232	9,804	38,646	18,012	10650
17-Jul	48,564	1,082	5,202	5,148	36,678	28,032	7140
18-Jul	4,971	503	2,286	6,558	22,470	27,102	5892
19-Jul	1,839	6,000	1,764	4,836	17,280	10,920	5094
20-Jul	2,543	12,882	990	1,674	20,934	26,256	5172
21-Jul	2,970	5,243			17,010	41,844	2538
22-Jul	1,650	3,580			14,064	24,762	
23-Jul	825				18,636		
24-Jul	1,188				9,486		
25-Jul	858						
26-Jul	264						
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	1,977,645	1,061,806	1,037,244	1,161,984	2,092,578	3,578,548	1,607,970

Appendix A. 4. Naknek River historical daily escapement, 1958-1999.

Date	1993	1994	1995	1996	1997	1998	1999
19-Jun							
20-Jun							
21-Jun	22,224	54	0	30			
22-Jun	4,728	1,110	1,158	744	1,062		
23-Jun	3,396	132	1,284	23,256	2,220	96	
24-Jun	15,972	600	1,416	31,350	8,202	1,482	2,724
25-Jun	93,438	3,246	130,218	56,742	13,044	9,858	1,374
26-Jun	86,598	1,698	66,198	19,572	19,812	8,538	564
27-Jun	65682	1596	25,686	23,658	6,996	10,848	4,122
28-Jun	46548	660	11,592	6,990	4,092	11,592	4,836
29-Jun	11478	1644	42,264	105,000	3,384	9,546	104,754
30-Jun	25104	7338	37,572	43,110	16,518	14,904	147,564
01-Jul	10518	15558	12,402	41,418	33,990	12,426	92,658
02-Jul	14274	89922	26,394	23,784	17,676	125,016	118,254
03-Jul	131280	188568	9,858	157,782	25,482	112,272	71,046
04-Jul	433860	61512	32,166	40,638	70,116	131,004	172,548
05-Jul	150006	37368	142,962	12,720	75,858	147,930	205,380
06-Jul	27960	58176	93,672	40,842	129,936	60,834	96,000
07-Jul	64488	40092	25,614	83,100	90,582	109,308	26,982
08-Jul	82314	113640	156,126	158,874	112,380	74,526	10,686
09-Jul	39594	53082	23,688	22,644	152,988	111,630	19,968
10-Jul	50436	43278	10,854	16,350	52,878	93,306	38,598
11-Jul	49842	30180	46,740	13,314	9,210	18,150	71,718
12-Jul	9000	44736	68,088	22,398	57,078	28,476	114,390
13-Jul	18558	17670	23,040	13,194	54,066	37,758	52,980
14-Jul	6132	17880	4,776	8,238	15,468	11,682	41,568
15-Jul	6918	23196	23,172	30,642	28,632	5,730	107,958
16-Jul	23454	30714	9,318	9,942	11,394	28,002	80,106
17-Jul	7212	39672	50,232	17,544	6,768	7,320	15,726
18-Jul	21294	44376	5,922	32,868	5,832	6,858	8,682
19-Jul	3336	11790	8,010	12,084		13,080	14,178
20-Jul	5232	2868	6,984	9,270			
21-Jul	3174	8454	13,734				
22-Jul	1608						
23-Jul							
24-Jul							
25-Jul							
26-Jul							
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
Total	1,537,651	992,804	1,113,135	1,080,094	1,027,661	1,204,170	1,627,363

Appendix A.5. Nuyakuk River historical daily escapement, 1959-1999.

Date	1959	1960	1961	1962	1963	1964	1965	1966
23-Jun								
24-Jun								
25-Jun								
26-Jun								
27-Jun								
28-Jun								
29-Jun								
30-Jun								
1-Jul								
2-Jul								
3-Jul					390			
4-Jul					1,140			
5-Jul	498				1,788		36	
6-Jul	492				2,862		156	
7-Jul	2,442	144	1,896	942	2,184		174	
8-Jul	3,363	594	9,192	2,148	870	102	156	12
9-Jul	3,213	888	10,698	1,740	23,490	384	18	120
10-Jul	5,637	1,848	7,044	1,752	47,016	2,316	30	210
11-Jul	6,321	8,430	6,864	6,582	40,116	3,864	48	318
12-Jul	3,597	37,290	3,462	7,098	17,472	8,754	960	402
13-Jul	3,849	38,952	2,544	5,844	7,398	7,968	5,286	546
14-Jul	2,526	28,830	5,508	3,600	3,786	16,806	29,190	2,280
15-Jul	2,208	12,330	6,150	3,372	9,468	27,438	44,688	44,856
16-Jul	1,656	4,896	4,980	1,866	2,940	22,512	30,366	48,702
17-Jul	930	5,328	6,642	834	1,566	6,588	18,210	25,278
18-Jul	384	3,636	5,922	996	1,116	1,440	22,650	10,914
19-Jul	399	1,488	3,840	414	588	912	15,930	9,060
20-Jul	1,533	300	2,088	324	738	768	8,700	7,656
21-Jul	1,485	156	756	120	510	762	6,060	4,458
22-Jul	1,344	78	426	42	222	288	3,486	2,406
23-Jul	1,371	18	372	42	252	108	2,460	1,284
24-Jul	1,326	0	354	18	66	48	2,016	1,026
25-Jul	675	0	222	24	126	108	2,484	432
26-Jul	639	6	162	24	90	210	1,464	162
27-Jul	411	6	114	12	132	318	1,830	48
28-Jul	381	12	150	12	114	192	894	78
29-Jul	411	36	138	18	102	168	1,080	60
30-Jul	249	0	66	6	54	84	708	90
31-Jul	291	12	66	12	12	180	1,002	30
1-Aug	324	18	84	6		78	822	102
2-Aug	354	36	48	12		12	384	54
3-Aug	225	0		0		96	300	36
4-Aug	117	6		6		102	234	72
5-Aug	96	0		6		60	192	6
6-Aug	114	0		0		96	288	30
7-Aug		0		6		72	306	60
8-Aug		0		0		66	462	42
9-Aug		12		0		132		60
10-Aug		36		0		84		54
11-Aug		30		0		108		66
12-Aug		0		0				
13-Aug		6		12				
14-Aug		78						
Total	48,861	145,500	79,788	37,890	166,608	103,224	203,070	161,010

Appendix A.5. Nuyakuk River historical daily escapement, 1959-1999.

Date	1967	1968	1969	1970	1971	1972	1973	1974
23-Jun								
24-Jun								
25-Jun								
26-Jun								
27-Jun								
28-Jun								
29-Jun	0	30	0				0	
30-Jun	0	624	0			0	0	
1-Jul	36	456	0			0	0	108
2-Jul	180	1,326	0			0	0	180
3-Jul	252	3,192	0			0	0	1,350
4-Jul	516	5,196	0			0	0	12,714
5-Jul	240	4,176	0			0	0	22,860
6-Jul	390	5,778	6			0	0	19,338
7-Jul	1,074	5,004	12	4		0	102	17,802
8-Jul	1,302	7,062	96	102		12	702	19,080
9-Jul	3,498	12,126	1,020	1,254	18	0	1,806	21,024
10-Jul	4,776	15,162	5,058	8,808	18	12	930	15,402
11-Jul	2,226	11,070	11,304	18,588	168	18	1,350	9,096
12-Jul	1,248	6,990	14,982	32,526	426	42	5,802	4,206
13-Jul	1,452	4,704	13,926	103,770	642	126	11,292	1,944
14-Jul	1,020	2,838	7,488	62,898	1,272	1,308	17,898	984
15-Jul	582	3,462	3,078	46,044	3,366	1,722	17,148	1,092
16-Jul	252	3,180	3,438	27,618	13,728	2,532	10,170	1,146
17-Jul	300	1,788	2,400	15,834	18,744	6,558	8,586	930
18-Jul	282	816	1,554	14,052	7,740	3,528	10,044	846
19-Jul	180	528	1,086	12,054	13,464	2,766	8,820	498
20-Jul	114	192	1,458	5,898	30,546	3,378	6,432	336
21-Jul	132	174	1,050	3,198	22,950	2,004	4,662	360
22-Jul	126	264	612	3,294	27,930	1,014	1,824	384
23-Jul	72	168	720	2,688	20,412	966	546	288
24-Jul		78	474	1,212	16,146	660	420	330
25-Jul		72	54	912	16,248	420	516	384
26-Jul		60	12	888	8,268	324	288	210
27-Jul		60		792	6,570	360	210	258
28-Jul		48		402	5,484	162	168	252
29-Jul		18		294	3,168	156	192	108
30-Jul		0		270	2,640	90	108	216
31-Jul				288	1,398	54		102
1-Aug				192	786	48		210
2-Aug				294	774	18		162
3-Aug				108	846	108		48
4-Aug				168	474	144		60
5-Aug				126	126	42		114
6-Aug				72		24		120
7-Aug								72
8-Aug								
9-Aug								
10-Aug								
11-Aug								
12-Aug								
13-Aug								
14-Aug								
Total	20,250	96,642	69,828	364,648	224,352	28,596	110,016	154,614

Appendix A.5. Nuyakuk River historical daily escapement, 1959-1999.

Date	1975	1976	1977	1978	1979	1980	1981
23-Jun							
24-Jun							
25-Jun							0
26-Jun							0
27-Jun							702
28-Jun							900
29-Jun	0			3,966			1,752
30-Jun	0			5,520	168		2,214
1-Jul	0	0	0	7,806	3,510	0	2,406
2-Jul	0	0	0	3,768	24,492	0	1,068
3-Jul	0	0	0	20,574	46,746	0	2,346
4-Jul	0	0	0	67,746	26,124	0	5,982
5-Jul	0	0	6	59,658	12,006	12,126	36,018
6-Jul	0	336	0	47,616	49,326	69,708	31,146
7-Jul	0	90	0	51,558	55,206	150,840	36,732
8-Jul	288	276	36	58,512	38,208	153,810	79,860
9-Jul	1,608	1,740	540	64,158	17,340	200,298	118,062
10-Jul	2,736	18,186	43,344	43,584	11,448	253,344	126,396
11-Jul	2,016	44,490	45,492	48,102	33,198	214,602	96,288
12-Jul	73,860	39,780	30,432	21,300	21,660	293,694	91,848
13-Jul	153,084	33,684	17,496	16,812	9,486	182,532	56,316
14-Jul	129,468	25,710	14,088	14,370	3,084	231,180	43,002
15-Jul	36,666	42,468	8,670	12,828	2,334	200,340	32,586
16-Jul	35,310	50,298	7,890	8,154	2,316	239,814	25,146
17-Jul	64,650	49,296	8,178	5,736	2,400	210,690	13,500
18-Jul	43,722	44,514	8,442	2,280	1,068	183,822	7,818
19-Jul	71,694	22,818	6,888	3,660		152,928	6,168
20-Jul	25,800	11,004	7,212	1,986		126,690	5,244
21-Jul	10,176	6,756	4,704	1,386		86,400	5,928
22-Jul	6,156	6,846	2,196	1,140		34,386	3,600
23-Jul	5,634	12,252	696	960		15,792	1,176
24-Jul	4,410	4,500	2,352	840		8,334	
25-Jul	1,632	2,208	1,572	606		2,388	
26-Jul	822	1,176	2,256	846		1,128	
27-Jul	186	924	1,656	282		426	
28-Jul		738	2,106	264		366	
29-Jul		690	3,156	228		378	
30-Jul		756	1,416	282		552	
31-Jul		624	2,412	138			
1-Aug		690	2,700				
2-Aug		594	1,482				
3-Aug		756	1,758				
4-Aug		846	1,752				
5-Aug		174	1,356				
6-Aug			270				
7-Aug							
8-Aug							
9-Aug							
10-Aug							
11-Aug							
12-Aug							
13-Aug							
14-Aug							
Total	669,918	425,220	232,554	576,666	360,120	3,026,568	834,204

Appendix A.5. Nuyakuk River historical daily escapement, 1959-1999.

Date	1982	1983	1984	1985	1986	1987	1988	1989-94
23-Jun								
24-Jun								
25-Jun								
26-Jun								
27-Jun								PROJECT
28-Jun				0				NOT
29-Jun			600	0				OPERATED
30-Jun		0	1,896	0				
1-Jul		0	18,654	0	0		7,362	
2-Jul		22,920	56,100	0	0		19,926	
3-Jul		27,078	17,130	0	96		13,080	
4-Jul	0	17,046	8,568	0	270		8,844	
5-Jul	1,812	12,054	28,542	5,322	342		3,996	
6-Jul	44,958	7,026	53,040	35,040	198		1,854	
7-Jul	66,798	22,212	44,064	51,264	174		5,520	
8-Jul	62,280	66,474	31,014	47,310	1,656		18,858	
9-Jul	73,410	54,462	33,858	32,262	13,518	11,028	29,736	
10-Jul	71,610	41,346	45,336	26,604	35,532	16,938	26,976	
11-Jul	76,056	21,462	31,872	14,004	41,766	11,244	11,862	
12-Jul	47,190	13,056	30,576	33,354	40,938	7,074	12,114	
13-Jul	31,830	4,698	24,336	33,156	50,688	14,826	28,614	
14-Jul	18,234	3,972	15,888	16,446	76,164	5,250	34,602	
15-Jul	11,568	2,154	11,202	8,766	78,960	1,578	35,154	
16-Jul	9,564	930	6,408	7,992	67,938	1,620	40,008	
17-Jul	6,648	522	3,516	5,322	97,860	204	13,464	
18-Jul	4,476	648	1,968	11,598	101,052		3,234	
19-Jul	2,706	546	702	26,910	79,194		2,052	
20-Jul	2,154		540	22,302	46,146		1,944	
21-Jul	1,008		1,410	23,178	35,922		792	
22-Jul	852		1,098	8,100	20,604			
23-Jul	1,464		648	3,738	32,880			
24-Jul	1,182		576	4,608				
25-Jul	522		768	4,560				
26-Jul	468		738	2,562				
27-Jul	366		636	1,866				
28-Jul	336		546	1,482				
29-Jul	288		180	936				
30-Jul	84		102	480				
31-Jul			84					
1-Aug								
2-Aug								
3-Aug								
4-Aug								
5-Aug								
6-Aug								
7-Aug								
8-Aug								
9-Aug								
10-Aug								
11-Aug								
12-Aug								
13-Aug								
14-Aug								
Total	537,864	318,606	472,596	429,162	821,898	69,762	319,992	

Appendix A.5. Nuyakuk River historical daily escapement, 1959-1999.

Date	1995	1996	1997	1998	1999
23-Jun					
24-Jun					
25-Jun					
26-Jun					
27-Jun					
28-Jun					
29-Jun					
30-Jun			9,618		
1-Jul			10,878		
2-Jul	570	4,752	9,666	90	
3-Jul	1,800	8,682	10,146	210	
4-Jul	4,530	9,576	14,460	732	60
5-Jul	8,346	8,004	17,172	2,052	420
6-Jul	5,988	8,220	16,080	3,834	4,086
7-Jul	1,986	10,212	25,764	4,908	6,654
8-Jul	1,842	10,674	21,990	7,890	15,108
9-Jul	2,268	18,396	12,648	21,168	10,242
10-Jul	2,358	33,396	10,206	29,496	10,578
11-Jul	3,012	29,994	7,362	20,112	10,134
12-Jul	8,478	12,732	7,392	22,506	7,020
13-Jul	10,200	11,442	8,454	11,658	4,560
14-Jul	6,306	9,414	8,628	8,028	948
15-Jul	2,628	15,534	10,074	4,512	1,248
16-Jul	2,574	10,926	15,102	2,178	1,464
17-Jul	1,926	4,236	12,084	1,902	1,950
18-Jul	948	4,566	9,960	1,818	1,560
19-Jul	1,110	3,564	7,656	1,044	786
20-Jul	708	6,660	8,016	912	456
21-Jul	330	4,398	5,034	1,200	462
22-Jul	744	3,624	5,436		840
23-Jul	666	3,936	3,306		882
24-Jul	384	3,246	1,392		594
25-Jul		5,178	1,440		390
26-Jul		4,392	3,018		564
27-Jul		4,938			
28-Jul					
29-Jul					
30-Jul					
31-Jul					
1-Aug					
2-Aug					
3-Aug					
4-Aug					
5-Aug					
6-Aug					
7-Aug					
8-Aug					
9-Aug					
10-Aug					
11-Aug					
12-Aug					
13-Aug					
14-Aug					
Total	69,702	250,692	272,982	146,250	81,006

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Appendix A.6. Togiak River historical daily escapement, 1960-1999.

Date	1960	1961	1962	1963	1964	1965	1966	1967	1968
26-Jun									
27-Jun									
28-Jun									
29-Jun									
30-Jun									
01-Jul									
02-Jul									258
03-Jul		0							804
04-Jul		42	6					0	1,980
05-Jul		84	54				6	888	1,344
06-Jul		0	156			24	66	2,580	1,518
07-Jul		876	66	120		0	84	2,862	1,758
08-Jul	0	1,050	492	1,164		30	120	1,476	2,028
09-Jul	219	3,348	1,026	2,220	42	264	282	864	1,710
10-Jul	3,738	4,818	972	4,914	1,338	1,224	138	1,008	1,158
11-Jul	4,875	4,194	2,448	10,206	1,338	3,720	288	684	1,620
12-Jul	6,234	3,696	3,486	12,582	3,120	6,378	216	1,470	3,654
13-Jul	7,728	3,294	5,334	4,554	1,602	2,382	282	2,280	1,416
14-Jul	8,739	4,374	3,720	5,376	3,534	4,188	1,140	3,942	3,006
15-Jul	7,281	5,736	3,240	3,702	4,818	2,790	4,476	4,542	1,386
16-Jul	7,680	6,162	2,478	1,266	3,822	4,572	9,396	2,262	1,854
17-Jul	6,852	4,176	2,568	3,630	1,056	2,442	8,726	2,142	2,028
18-Jul	5,190	3,078	2,754	3,972	2,496	1,986	6,060	2,424	1,602
19-Jul	7,050	3,942	2,868	3,474	3,078	1,968	5,262	2,958	1,074
20-Jul	6,366	6,126	948	6,066	2,136	3,096	9,258	3,048	498
21-Jul	5,862	5,874	510	3,180	2,448	6,342	7,092	2,502	774
22-Jul	5,112	3,084	804	1,998	4,770	5,004	7,056	5,172	822
23-Jul	5,346	2,328	1,290	2,460	9,210	5,730	4,338	4,332	228
24-Jul	5,190	1,164	942	2,874	7,998	4,122	3,804	4,488	1,020
25-Jul	4,680	1,368	414	3,912	3,702	1,494	2,160	5,034	1,080
26-Jul	2,598	1,686	546	3,822	2,922	2,940	3,048	4,512	360
27-Jul	3,672	2,208	1,626	1,788	2,394	2,730	2,160	3,594	876
28-Jul	4,422	2,970	1,092	1,026	1,980	2,496	2,670	2,136	360
29-Jul	6,510	4,098	1,470	1,968	1,704	3,474	1,938	1,242	540
30-Jul	5,004	2,484	738	954	4,824	2,388	1,230	450	444
31-Jul	3,378	1,662	144	4,386	4,428	1,878	1,044	180	354
01-Aug	1,608	1,380	432	4,104	3,252	1,222	942	108	720
02-Aug	3,522	966	324	2,328	3,804	1,272	1,098	54	702
03-Aug	5,418	2,166	564	1,788	1,866	1,554	570	96	342
04-Aug	5,244	1,866	708	1,074	2,292	654	1,026	0	372
05-Aug	5,070	1,134	396	630	1,416	882	1,638		522
06-Aug	4,926	1,638	72	264	1,626	1,344	942		180
07-Aug	4,710	786	384	102	1,374	804	708		312
08-Aug	3,300	282	336	48	948	888	180		492
09-Aug	2,088	504	384	54	1,164	594	204		108
10-Aug	1,878	144	240	264	858	978	102		594
11-Aug	1,320	252	510	126	456	840	168		486
12-Aug		192	216	0	540	492	138		162
13-Aug		222	378	0	366	486	42		156
14-Aug			120	0	252	342			120
15-Aug			84		276	366			72
16-Aug			0		228	618			24
17-Aug			12		96	432			
18-Aug						438			
19-Aug						462			
20-Aug						156			
Total	162,810	95,454	47,352	102,396	95,574	88,486	91,098	69,330	42,918

Appendix A.6. Togiak River historical daily escapement, 1960-1999.

Date	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
26-Jun										
27-Jun										60
28-Jun										510
29-Jun										6,930
30-Jun										8,328
01-Jul					6	606	0		0	3,126
02-Jul		162			0	2,526	0	0	0	3,228
03-Jul		210			0	1,236	0	0	0	5,640
04-Jul		2,586			24	342	0	0	54	8,646
05-Jul	0	6,930			60	1,830	0	0	150	14,646
06-Jul	2,190	5,166		6	54	1,068	0	0	804	7,998
07-Jul	954	4,128	12	6	60	7,344	0	30	6,858	7,260
08-Jul	804	11,400	0	36	2,952	5,022	18	42	4,926	5,742
09-Jul	5,352	11,484	0	24	4,500	3,144	330	570	5,460	9,132
10-Jul	8,100	7,824	0	24	3,600	4,176	792	4,218	6,678	8,556
11-Jul	8,844	7,332	42	6	4,968	6,180	5,886	5,484	8,412	12,594
12-Jul	5,916	5,772	120	60	5,100	4,428	12,420	5,322	11,550	19,602
13-Jul	4,242	2,316	96	78	5,340	3,726	6,768	6,480	11,082	19,254
14-Jul	3,120	4,278	18	84	6,588	2,706	9,948	7,554	10,650	15,702
15-Jul	1,830	10,164	4,986	4,212	4,176	1,914	12,618	8,724	8,142	11,664
16-Jul	2,412	9,696	4,386	3,726	5,334	2,094	20,670	11,334	2,982	10,488
17-Jul	6,582	10,968	9,408	1,128	5,256	3,456	11,790	10,620	2,754	8,946
18-Jul	5,718	8,370	6,558	4,236	5,898	2,310	17,988	8,280	2,760	7,176
19-Jul	4,392	5,964	7,026	4,554	7,530	2,712	6,684	7,926	5,160	11,574
20-Jul	3,876	6,432	12,660	3,852	5,700	6,702	10,128	7,050	6,804	9,636
21-Jul	2,856	5,880	8,556	4,428	5,388	4,578	7,500	9,480	6,744	8,328
22-Jul	1,332	4,554	8,622	4,770	3,864	3,246	5,376	7,566	4,458	6,072
23-Jul	3,234	4,506	17,232	6,858	2,976	3,990	6,126	9,972	2,928	3,810
24-Jul	2,886	5,322	10,140	6,570	1,938	2,388	5,364	9,486	2,178	2,682
25-Jul	1,176	5,670	9,756	6,414	1,326	2,718	6,030	5,574	1,770	2,724
26-Jul	2,340	3,090	8,178	6,078	2,508	1,806	2,712	4,290	1,374	3,534
27-Jul	1,536	5,940	14,928	7,032	2,316	384	3,096	2,754	1,848	4,008
28-Jul	3,246	3,378	11,946	2,820	1,560	(288)	1,704	3,084	2,280	7,272
29-Jul	1,518	3,306	7,734	3,066	1,062	492	2,292	4,506	1,020	6,156
30-Jul	2,778	3,378	6,516	1,620	1,752	(366)	1,410	7,272	2,436	3,528
31-Jul	2,754	3,024	5,430	1,104	1,464	(192)	1,362	2,604	2,616	3,282
01-Aug	2,976	1,758	3,186	876	708	426	462	3,522	2,064	2,250
02-Aug	2,628	2,274	2,304	354	642	198	744	2,340	1,668	2,358
03-Aug	3,546	2,706	2,886	48	1,050	90	396	1,644	2,502	972
04-Aug	2,340	2,610	2,454		(6)		348	390	2,154	162
05-Aug	1,644	1,890	3,414		36			72	468	
06-Aug	1,248	2,136	2,286							
07-Aug	588	672	2,370							
08-Aug	1,200	2,304	2,316							
09-Aug	582	1,170	2,154							
10-Aug	1,320	1,020	2,082							
11-Aug	636	954	1,794							
12-Aug	432	738	1,548							
13-Aug	102	978	1,674							
14-Aug	36	708	1,890							
15-Aug		390	1,542							
16-Aug		210	1,482							
17-Aug		336	798							
18-Aug		12	312							
19-Aug										
20-Aug										
Total	109,266	192,096	190,842	74,070	95,730	82,992	160,962	158,190	133,734	273,576

Appendix A.6. Togiak River historical daily escapement, 1960-1999.

Date	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
26-Jun					36		0			
27-Jun			0		0		0			
28-Jun	66	12	0		0	42	0			
29-Jun	708	0	0		0	444	0			
30-Jun	498	0	0	12	606	396	0			
01-Jul	2,484	0	0	162	2,394	672	0			2,070
02-Jul	804	0	0	18	4,386	630	0	0		3,456
03-Jul	2,904	546	0	108	2,964	246	0	0		4,938
04-Jul	2,700	2,952	786	246	1,452	792	0	72		4,248
05-Jul	6,942	9,636	684	1,056	2,574	1,674	6	348		5,826
06-Jul	5,952	15,294	1,776	2,124	5,136	1,026	42	72	0	16,404
07-Jul	2,454	23,352	3,276	4,686	6,054	3,186	18	198	1,920	29,400
08-Jul	3,522	11,058	8,376	7,782	6,486	1,824	54	378	9,060	21,996
09-Jul	3,576	10,998	12,756	10,602	5,076	3,246	144	714	8,202	13,038
10-Jul	5,688	9,420	9,342	9,690	5,178	2,886	438	858	7,548	9,072
11-Jul	9,312	17,742	6,456	7,500	5,364	3,546	3,954	2,028	7,356	7,386
12-Jul	11,556	26,238	6,060	10,482	8,928	6,450	5,178	678	7,404	8,784
13-Jul	6,624	25,662	4,338	9,750	14,856	6,426	5,646	1,458	9,546	14,424
14-Jul	4,242	26,442	5,010	13,320	17,274	5,064	6,198	1,902	12,294	17,046
15-Jul	3,852	31,806	5,202	17,226	10,662	4,470	4,392	4,488	14,844	7,938
16-Jul	3,330	30,894	7,824	12,246	5,874	2,658	3,384	5,778	12,492	11,550
17-Jul	9,000	38,754	13,044	8,556	5,628	3,096	4,254	8,946	7,464	8,964
18-Jul	11,376	28,872	12,378	3,492	3,384	4,248	5,988	10,374	5,070	6,606
19-Jul	13,350	39,180	7,920	5,340	5,646	5,832	4,524	5,130	7,422	10,728
20-Jul	9,294	21,558	6,018	5,610	7,422	3,822	8,016	4,512	10,758	16,656
21-Jul	4,860	20,574	7,374	6,270	6,360	3,552	6,042	5,520	17,682	10,764
22-Jul	3,978	25,272	7,038	9,792	5,256	2,142	7,578	7,074	13,932	5,658
23-Jul	2,796	14,658	8,358	10,236	3,204	1,620	5,820	6,558	15,594	7,578
24-Jul	2,088	10,548	8,100	5,418	1,578	1,122	8,232	10,428	9,948	9,474
25-Jul	2,706	11,958	7,872	3,546	2,022	2,244	8,406	6,036	4,716	2,874
26-Jul	4,566	2,700	10,080	3,918	4,326	2,088	10,710	8,700	4,362	6,996
27-Jul	5,658	2,472	7,704	4,938	3,528	4,236	6,288	6,264	4,020	3,816
28-Jul	5,322	2,100	5,418	5,316	3,492	2,448	6,942	5,226	4,692	3,468
29-Jul	3,720	852	7,854	5,370	3,600	2,592	6,414	5,280	7,788	2,568
30-Jul	3,072	300	6,048	7,242	5,220	1,002	4,614	7,836	12,780	1,458
31-Jul	3,870		5,928	8,580	3,492	984	3,798	8,406	8,142	792
01-Aug	3,168		6,780	10,242	4,374	1,164	3,660	9,456	4,164	636
02-Aug	4,416		2,952	6,828	4,422	1,032	2,466	8,394	3,828	
03-Aug	684		2,040	5,844	4,902	738	1,356	7,050	2,346	
04-Aug			2,112	4,308	4,224	1,236	822	5,376	1,584	
05-Aug			1,176	3,360	2,592	1,236	450	5,430	2,754	
06-Aug				3,426	1,206	600	612	4,206	5,040	
07-Aug				2,730	342	1,380	96	1,524	1,272	
08-Aug				2,376		690		1,686	1,056	
09-Aug				2,328		552			1,002	
10-Aug				1,746		114			884	
11-Aug				912					710	
12-Aug										
13-Aug										
14-Aug										
15-Aug										
16-Aug										
17-Aug										
18-Aug										
19-Aug										
20-Aug										
Total	171,138	461,850	208,080	244,734	191,520	95,448	136,542	168,384	249,676	276,612

Appendix A.6. Togiak River historical daily escapement, 1960-1999.

Date	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
26-Jun										
27-Jun										
28-Jun										12
29-Jun					36					0
30-Jun					4,443					0
01-Jul				0	5,432					0
02-Jul				36	5,334		0			0
03-Jul	72	84	12	0	5,472		780	1,344	54	0
04-Jul	72	1,062	396	1,002	3,714		1,290	2,208	342	0
05-Jul	78	2,142	4,206	810	3,840		3,966	2,310	264	0
06-Jul	852	852	7,530	1,800	1,890		3,384	1,218	354	12
07-Jul	1,794	516	7,512	4,128	3,534	192	3,630	702	30	186
08-Jul	2,460	1,206	4,656	10,386	3,204	558	1,890	858	54	12
09-Jul	3,828	1,950	11,124	9,060	5,604	648	3,660	804	186	30
10-Jul	2,730	2,220	16,914	6,120	5,232	144	5,106	1,938	366	0
11-Jul	3,210	4,344	18,876	5,040	6,420	672	6,606	4,626	906	306
12-Jul	5,646	4,770	9,990	4,182	5,106	1,650	12,282	6,246	750	4,914
13-Jul	4,686	5,424	7,578	3,852	14,514	3,306	11,088	3,468	1,386	1,410
14-Jul	2,604	3,384	6,180	4,584	15,372	6,420	7,344	6,138	6,906	1,170
15-Jul	1,452	1,392	7,800	12,450	14,190	7,656	4,434	6,258	4,866	4,446
16-Jul	1,560	3,414	16,314	21,414	7,596	4,884	4,674	7,128	4,542	8,370
17-Jul	828	4,164	14,394	12,966	5,106	5,016	3,642	5,814	4,482	5,712
18-Jul	2,148	5,328	16,434	5,070	4,158	3,702	5,574	7,098	3,480	3,510
19-Jul	2,406	4,122	12,774	5,298	2,364	2,544	16,848	7,860	4,008	3,678
20-Jul	2,940	5,118	9,000	3,900	2,226	5,736	18,936	5,844	4,674	5,100
21-Jul	4,326	4,728	6,786	4,710	4,986	10,698	19,716	6,330	2,712	4,896
22-Jul	6,234	4,998	6,630	8,724	5,766	8,538	12,756	7,236	5,364	5,766
23-Jul	5,328	5,244	5,790	14,124	4,470	5,826	5,832	12,720	6,300	11,268
24-Jul	5,598	4,824	4,014	9,804	2,976	3,024	4,476	11,046	9,228	9,174
25-Jul	3,360	9,414	6,114	6,432	3,054	4,464	3,024	13,842	8,742	6,378
26-Jul	3,666	6,660	3,366	3,660	3,072	5,310	2,826	9,204	4,902	6,750
27-Jul	4,308	2,832	1,884	2,724	3,264	8,754	2,226	7,224	5,568	5,400
28-Jul	1,992	4,284	480	3,000	5,196	15,702	2,736	6,858	5,982	8,100
29-Jul	2,148	6,282	3,606	4,302	3,408	8,826	1,176	3,126	5,874	7,866
30-Jul	1,650	3,642	5,454	6,678	2,832	5,880	2,250	3,768	6,396	8,016
31-Jul	948	3,708	10,062	4,890	1,968	4,722	1,518	1,668	8,016	5,592
01-Aug	1,098	3,702	6,204	4,776	3,192	3,942	2,754	2,070	4,230	5,892
02-Aug	1,020	5,370	4,446	4,068	4,218	3,786	4,644		4,368	5,298
03-Aug	1,284	5,136	2,010	3,822	1,980	2,334	2,028		2,970	6,570
04-Aug	990	4,056	3,204	2,082	1,008	2,742	960		4,428	7,344
05-Aug	438	2,118	2,634	3,240	1,008	4,902	828		2,790	2,676
06-Aug	456	3,084	3,828			5,556	510		3,126	4,668
07-Aug	270	2,046	6,481			3,066	324		1,338	3,054
08-Aug		1,620				2,436			972	
09-Aug		2,904				1,116			726	
10-Aug		3,833								
11-Aug										
12-Aug										
13-Aug										
14-Aug										
15-Aug										
16-Aug										
17-Aug										
18-Aug										
19-Aug										
20-Aug										
Total	84,480	141,977	254,683	199,134	177,185	154,752	185,718	156,954	131,682	153,576

Appendix A.6. Togiak River historical daily escapement, 1960-1999.

Date	1999
26-Jun	
27-Jun	
28-Jun	
29-Jun	
30-Jun	
01-Jul	
02-Jul	
03-Jul	
04-Jul	
05-Jul	36
06-Jul	1,746
07-Jul	6,246
08-Jul	4,782
09-Jul	3,222
10-Jul	3,108
11-Jul	4,740
12-Jul	5,040
13-Jul	4,602
14-Jul	3,762
15-Jul	2,550
16-Jul	2,598
17-Jul	4,362
18-Jul	3,750
19-Jul	2,910
20-Jul	3,054
21-Jul	3,030
22-Jul	9,192
23-Jul	6,864
24-Jul	2,856
25-Jul	4,098
26-Jul	6,012
27-Jul	18,354
28-Jul	19,374
29-Jul	13,122
30-Jul	6,174
31-Jul	3,378
01-Aug	3,402
02-Aug	1,848
03-Aug	1,182
04-Aug	504
05-Aug	
06-Aug	
07-Aug	
08-Aug	
09-Aug	
10-Aug	
11-Aug	
12-Aug	
13-Aug	
14-Aug	
15-Aug	
16-Aug	
17-Aug	
18-Aug	
19-Aug	
20-Aug	
Total	155,898

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1957	1958	1959	1960	1961	1962	1963
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun							
28-Jun							
29-Jun							
30-Jun							
01-Jul				0			
02-Jul				0			
03-Jul	0			0		2,268	
04-Jul	0	4,992		0		606	
05-Jul	361	15,012		0		90	
06-Jul	0	26,514		0	1,110	18	0
07-Jul	296	39,594		0	1,392	18	78
08-Jul	10	7,938	0	0	2,328	4,986	66
09-Jul	126	15,726	2,535	0	9,174	20,460	18
10-Jul	8,514	18,540	29,589	0	5,106	9,498	18
11-Jul	5,754	20,226	25,845	30	1,560	6,966	12
12-Jul	2,994	15,726	20,646	45,672	3,744	5,280	30
13-Jul	12,528	11,202	12,336	200,282	1,980	1,464	90
14-Jul	13,056	26,170	5,715	299,628	38,385	144	27,726
15-Jul	19,434	8,712	2,712	220,122	97,302	18	181,038
16-Jul	19,771	10,740	19,869	59,250	39,786	133,980	30,804
17-Jul	33,420	11,994	5,743	38,310	28,962	49,890	23,400
18-Jul	28,908	6,774	11,277	261,470	24,042	4,662	43,338
19-Jul	10,530	7,110	16,806	508,176	39,972	2,136	19,482
20-Jul	4,208	8,898	4,608	216,636	4,050	5,112	13,152
21-Jul	7,215	2,010	6,477	179,238	10,584	834	11,652
22-Jul	2,560	3,600	7,701	146,988	9,708	888	4,638
23-Jul	3,292	2,586	6,192	53,256	10,410	294	1,980
24-Jul	2,880	1,620	7,707	8,628	5,655	480	4,380
25-Jul	8,394	1,572	4,460	17,970	3,795	42	6,522
26-Jul	5,988	798	4,984	5,592	930	1,740	1,194
27-Jul	1,096	1,608	5,508	5,214	726	546	3,048
28-Jul	1,730	1,476	1,863	7,146	924	228	7,254
29-Jul	4,482	1,164	1,719	1,842	630	678	6,486
30-Jul	448	1,674	2,213	6,702	1,314	300	1,092
31-Jul	6,509	1,416	1,335	3,324	1,380	762	636
01-Aug	2,184	2,364	2,002	3,012	940	198	78
02-Aug	1,156	570	2,289	2,448	858	360	12
03-Aug	1,396	408	1,655	1,266	468	192	30
04-Aug	1,132	144	1,393	444	543	84	0
05-Aug	513	516	1,521	1,554	153	174	
06-Aug	832	522	801		300	30	
07-Aug	1,864	516	1,320		285		
08-Aug	526	108	422		162		
09-Aug	695						
Total	214,802	279,540	219,223	2,294,200	348,658	255,426	388,254

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Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1964	1965	1966	1967	1968	1969	1970	1971
20-Jun								
21-Jun								
22-Jun								
23-Jun								
24-Jun								
25-Jun								
26-Jun								
27-Jun				0				
28-Jun				0	54			
29-Jun		0	0	0	48	0	0	0
30-Jun		0	0	0	36	0	0	0
01-Jul		42	0	0	42	0	0	0
02-Jul		102	0	0	36	0	0	0
03-Jul	0	0	0	0	1,110	0	0	0
04-Jul	0	0	0	0	8,166	0	24	0
05-Jul	0	0	0	4,962	918	0	24	0
06-Jul	0	78	0	44,652	2,496	0	30	0
07-Jul	0	12	0	41,148	5,478	0	54	0
08-Jul	0	5,010	0	17,016	6,036	1,638	0	0
09-Jul	114	6,990	0	13,998	8,886	288	30	0
10-Jul	0	2,622	0	23,670	5,880	96	4,242	0
11-Jul	0	3,090	75,060	12,108	4,074	42	149,436	0
12-Jul	77,130	8,754	77,976	9,180	3,396	30	41,382	0
13-Jul	71,100	3,006	25,590	5,148	1,812	24	24,468	12
14-Jul	47,418	7,854	66,048	456	1,932	35,250	49,398	0
15-Jul	33,252	36,354	53,412	168	1,602	97,392	90,114	0
16-Jul	41,448	145,932	28,950	372	1,266	7,074	94,038	12
17-Jul	66,192	70,404	76,938	168	6,576	2,820	22,788	42,996
18-Jul	24,138	69,060	6,816	30,504	2,766	3,288	69,450	195,816
19-Jul	8,856	34,314	246	22,242	1,572	1,602	81,666	24,264
20-Jul	45,876	60,444	85,116	3,372	1,272	2,298	69,306	18,780
21-Jul	20,334	63,750	148,296	2,166	978	1,344	12,240	41,928
22-Jul	4,476	60,150	42,150	2,544	624	1,836	-2,736	24,036
23-Jul	3,084	109,446	3,450	978	480	2,964	2,748	29,382
24-Jul	2,142	67,440	2,310	1,182	276	534	2,688	10,830
25-Jul	3,720	32,232	1,896	1,002	366	456	4,338	22,386
26-Jul	5,784	29,946	1,404	558	264	144	2,214	31,920
27-Jul	2,946	46,326	1,650	300	312	252	2,262	11,616
28-Jul	2,598	59,634	1,464	294	342	264	1,518	3,540
29-Jul	1,290	44,262	1,656	228	474	402	870	25,596
30-Jul	1,656	14,844	390	150	558	192	1,494	12,288
31-Jul	2,832	5,592	462	174	282	66	972	2,940
01-Aug	1,518	3,366	1,554	90	132	84	1,134	2,028
02-Aug	1,818							
03-Aug	642							
04-Aug	1,572							
05-Aug	834							
06-Aug								
07-Aug								
08-Aug								
09-Aug								
Total	472,770	991,056	702,834	238,830	70,542	160,380	726,192	500,370

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1957	1958	1959	1960	1961	1962	1963
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun							
28-Jun							
29-Jun							
30-Jun							
01-Jul				0			
02-Jul				0			
03-Jul	0			0		2,268	
04-Jul	0	4,992		0		606	
05-Jul	361	15,012		0		90	
06-Jul	0	26,514		0	1,110	18	0
07-Jul	296	39,594		0	1,392	18	78
08-Jul	10	7,938	0	0	2,328	4,986	66
09-Jul	126	15,726	2,535	0	9,174	20,460	18
10-Jul	8,514	18,540	29,589	0	5,106	9,498	18
11-Jul	5,754	20,226	25,845	30	1,560	6,966	12
12-Jul	2,994	15,726	20,646	45,672	3,744	5,280	30
13-Jul	12,528	11,202	12,336	200,282	1,980	1,464	90
14-Jul	13,056	25,170	5,715	299,628	38,385	144	27,726
15-Jul	19,434	8,712	2,712	220,122	97,302	18	181,038
16-Jul	19,771	10,740	19,869	59,250	39,786	133,980	30,804
17-Jul	33,420	11,994	5,743	38,310	28,962	49,890	23,400
18-Jul	28,908	6,774	11,277	261,470	24,042	4,662	43,338
19-Jul	10,530	7,110	16,806	508,176	39,972	2,136	19,482
20-Jul	4,208	8,898	4,608	216,636	4,050	5,112	13,152
21-Jul	7,215	2,010	6,477	179,238	10,584	834	11,652
22-Jul	2,560	3,600	7,701	146,988	9,708	888	4,638
23-Jul	3,292	2,586	6,192	53,256	10,410	294	1,980
24-Jul	2,880	1,620	7,707	8,628	5,655	480	4,380
25-Jul	8,394	1,572	4,460	17,970	3,795	42	6,522
26-Jul	5,988	798	4,984	5,592	930	1,740	1,194
27-Jul	1,096	1,608	5,508	5,214	726	546	3,048
28-Jul	1,730	1,476	1,863	7,146	924	228	7,254
29-Jul	4,482	1,164	1,719	1,842	630	678	6,486
30-Jul	448	1,674	2,213	6,702	1,314	300	1,092
31-Jul	6,509	1,416	1,335	3,324	1,380	762	636
01-Aug	2,184	2,364	2,002	3,012	940	198	78
02-Aug	1,156	570	2,269	2,448	858	360	12
03-Aug	1,396	408	1,655	1,266	468	192	30
04-Aug	1,132	144	1,393	444	543	84	0
05-Aug	513	516	1,521	1,554	153	174	
06-Aug	832	522	801		300	30	
07-Aug	1,864	516	1,320		285		
08-Aug	526	108	422		162		
09-Aug	695						
Total	214,802	279,540	219,223	2,294,200	348,658	255,426	388,254

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1964	1965	1966	1967	1968	1969	1970
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun				0			
28-Jun				0	54		
29-Jun		0	0	0	48	0	0
30-Jun		0	0	0	36	0	0
01-Jul		42	0	0	42	0	0
02-Jul		102	0	0	36	0	0
03-Jul	0	0	0	0	1,110	0	0
04-Jul	0	0	0	0	8,166	0	24
05-Jul	0	0	0	4,962	918	0	24
06-Jul	0	78	0	44,652	2,496	0	30
07-Jul	0	12	0	41,148	5,478	0	54
08-Jul	0	5,010	0	17,016	6,036	1,638	0
09-Jul	114	6,990	0	13,998	8,886	288	30
10-Jul	0	2,622	0	23,670	5,880	96	4,242
11-Jul	0	3,090	75,060	12,108	4,074	42	149,436
12-Jul	77,130	8,754	77,976	9,180	3,396	30	41,382
13-Jul	71,100	3,006	25,590	5,148	1,812	24	24,468
14-Jul	47,418	7,854	66,048	456	1,932	35,250	49,398
15-Jul	33,252	36,354	53,412	168	1,602	97,392	90,114
16-Jul	41,448	145,932	28,950	372	1,266	7,074	94,038
17-Jul	66,192	70,404	76,938	168	6,576	2,820	22,788
18-Jul	24,138	69,060	6,816	30,504	2,766	3,288	69,450
19-Jul	8,856	34,314	246	22,242	1,572	1,602	81,666
20-Jul	45,876	60,444	85,116	3,372	1,272	2,298	69,306
21-Jul	20,334	63,750	148,296	2,166	978	1,344	12,240
22-Jul	4,476	60,150	42,150	2,544	624	1,836	-2,736
23-Jul	3,084	109,446	3,450	978	480	2,964	2,748
24-Jul	2,142	67,440	2,310	1,182	276	534	2,688
25-Jul	3,720	32,232	1,896	1,002	366	456	4,338
26-Jul	5,784	29,946	1,404	558	264	144	2,214
27-Jul	2,946	46,326	1,650	300	312	252	2,262
28-Jul	2,598	59,634	1,464	294	342	264	1,518
29-Jul	1,290	44,262	1,656	228	474	402	870
30-Jul	1,656	14,844	390	150	558	192	1,494
31-Jul	2,832	5,592	462	174	282	66	972
01-Aug	1,518	3,366	1,554	90	132	84	1,134
02-Aug	1,818						
03-Aug	642						
04-Aug	1,572						
05-Aug	834						
06-Aug							
07-Aug							
08-Aug							
09-Aug							
Total	472,770	991,056	702,834	238,830	70,542	160,380	726,192

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1971	1972	1973	1974	1975	1976	1977
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun							
28-Jun							
29-Jun	0	0					
30-Jun	0	0					
01-Jul	0	0					
02-Jul	0	0				0	0
03-Jul	0	0				0	0
04-Jul	0	0				0	0
05-Jul	0	0	36	66	0	0	0
06-Jul	0	0	6	552	0	534	17,898
07-Jul	0	108	48	2,796	0	930	42,630
08-Jul	0	354	24	486	0	288	12,474
09-Jul	0	390	1,866	78	12	216	8,076
10-Jul	0	4,704	3,810	102	66	12	9,060
11-Jul	0	11,742	5,772	96	72	18	13,104
12-Jul	0	4,458	2,346	36	30	26,796	12,546
13-Jul	12	2,664	156	9,186	21,354	124,344	1,866
14-Jul	0	16,134	228	33,456	57,522	33,588	12,300
15-Jul	0	12,744	7,140	9,564	40,704	28,620	702
16-Jul	12	9,204	8,586	1,368	26,370	576	144
17-Jul	42,996	10,158	3,738	360	12,678	768	114
18-Jul	195,816	1,590	1,704	2,502	3,012	90	12
19-Jul	24,264	2,832	540	342	11,814	47,790	252
20-Jul	18,780	840	126	942	46,902	48,270	5,562
21-Jul	41,928	126	18	-144	99,246	4,284	38,868
22-Jul	24,036	234	762	66	64,518	3,168	11,136
23-Jul	29,382	468	984		18,390	1,560	9,246
24-Jul	10,830	534	684		13,596	2,148	1,326
25-Jul	22,386	48	330		9,474	4,290	1,578
26-Jul	31,920	96	60		3,144	2,490	972
27-Jul	11,616		24		-354	2,400	330
28-Jul	3,540				528	2,430	552
29-Jul	25,596				258	1,356	738
30-Jul	12,288					618	
31-Jul	2,940					1,164	
01-Aug	2,028					1,470	
02-Aug							
03-Aug							
04-Aug							
05-Aug							
06-Aug							
07-Aug							
08-Aug							
09-Aug							
Total	500,370	79,428	38,988	61,854	429,336	340,218	201,486

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1978	1979	1980	1981	1982	1983	1984
20-Jun				0		0	0
21-Jun				0		0	0
22-Jun				210		0	6
23-Jun				18		6	30
24-Jun				852		54	0
25-Jun				3,228		90	18
26-Jun				5,730		84	210
27-Jun				1,368		66	114
28-Jun				1,284		12	102
29-Jun				3,984		102	426
30-Jun				2,508		276	1,758
01-Jul		1,800	0	2,694	36	18	4,350
02-Jul		10,884	42	5,334	0	942	2,706
03-Jul		30,702	288	16,350	6	2,178	72
04-Jul		1,716	804	25,488	492	138	0
05-Jul		8,832	960	33,774	162	30	24
06-Jul	168	69,810	600	44,634	282	49,374	0
07-Jul	1,362	66,792	126	77,208	6,240	9,252	18
08-Jul	54	53,382	1,062	84,510	222	21,630	0
09-Jul	1,782	127,776	1,878	153,582	600	12,342	24
10-Jul	3,252	172,950	19,290	196,398	114	31,104	150
11-Jul	1,758	167,856	43,026	122,802	10,098	200,904	145,170
12-Jul	8,904	116,874	36,426	183,150	83,364	72,840	80,616
13-Jul	7,596	247,602	49,902	131,328	362,574	71,016	63,840
14-Jul	4,566	202,416	128,490	117,780	193,482	173,064	161,292
15-Jul	10,584	90,672	274,296	24,906	222,864	132,630	135,360
16-Jul	13,854	43,176	331,920	20,040	111,204	38,958	45,534
17-Jul	7,110	34,524	621,054	13,230	47,286	14,634	231,408
18-Jul	1,548	20,592	529,914	14,838	68,688	10,236	122,700
19-Jul	240	59,046	407,658	16,794	12,966	12,318	91,356
20-Jul	180	74,862	102,408	11,418	12,444	14,862	65,748
21-Jul	204	37,578	332,808	5,742	5,454	19,416	23,652
22-Jul	696	22,506	337,554	2,868	7,782	12,846	12,582
23-Jul	714	11,514	49,140	2,034	3,090	11,448	15,390
24-Jul	426	13,536	24,894	678	3,108	6,150	9,414
25-Jul	1,506	6,372	10,536		3,330	3,162	9,216
26-Jul	876	7,134	9,984		1,422	4,884	5,988
27-Jul	336		6,294		216	14,550	6,306
28-Jul	270					13,836	3,540
29-Jul	1,218					14,250	2,298
30-Jul	912					12,732	
31-Jul	318					9,684	
01-Aug						4,824	
02-Aug						3,462	
03-Aug						204	
04-Aug							
05-Aug							
06-Aug							
07-Aug							
08-Aug							
09-Aug							
Total	70,434	1,700,904	3,321,354	1,326,762	1,157,526	1,000,608	1,241,418

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1985	1986	1987	1988	1989	1990	1991
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun							
28-Jun	78						
29-Jun	96						
30-Jun	78						
01-Jul	132						
02-Jul	42		0				
03-Jul	60		0	0		474	186
04-Jul	42		4,218	3,792	210	774	114
05-Jul	12		1,332	1,968	66,222	1,404	246
06-Jul	17,580		918	1,296	80,304	2,484	204
07-Jul	107,766	36	6	312	101,388	816	1,344
08-Jul	26,382	264	2,514	360	67,650	11,316	206,874
09-Jul	24,060	192	29,172	3,240	66,516	21,192	203,916
10-Jul	564	84	27,996	750	58,008	28,512	63,720
11-Jul	546	174	2,424	642	101,514	52,932	20,352
12-Jul	90	144	468	504	413,310	88,320	264,186
13-Jul	156,342	60	198	11,694	220,854	119,148	570,204
14-Jul	249,198	358,878	3,030	66,366	63,300	98,910	224,910
15-Jul	145,356	287,286	120,300	96,690	66,618	55,200	484,884
16-Jul	27,666	40,518	310,194	130,008	54,420	51,414	139,578
17-Jul	11,388	46,542	45,252	35,340	58,482	32,592	31,296
18-Jul	16,890	58,950	5,874	53,004	68,544	57,162	22,488
19-Jul	4,584	43,158	4,308	54,756	47,448	29,988	20,754
20-Jul	14,970	14,796	4,596	36,426	30,702	15,666	33,942
21-Jul	5,580	9,396	5,736	29,826	20,934	13,992	24,816
22-Jul	7,854	29,520	7,626	25,806	15,210	7,428	46,530
23-Jul	14,328	34,680	11,802	21,198	13,212	2,604	51,000
24-Jul	20,382	9,602	6,858	11,016	15,138	4,470	16,236
25-Jul	13,272	9,602	4,590	14,778	20,838	3,018	9,996
26-Jul	40,356	9,602	11,172	25,980	18,528	3,438	7,446
27-Jul	37,422	9,602	18,756	6,126	7,578	7,104	5,910
28-Jul	16,086	9,602	6,120	2,334	2,004	9,870	6,174
29-Jul	9,984	9,602	11,142	2,220	2,364	9,810	
30-Jul	11,952	9,602	8,604	2,718			
31-Jul	8,574	9,600	7,242	2,070			
01-Aug	4,818		6,516	1,056			
02-Aug	2,496			696			
03-Aug	1,206						
04-Aug							
05-Aug							
06-Aug							
07-Aug							
08-Aug							
09-Aug							
Total	998,232	1,001,492	668,964	642,972	1,681,296	730,038	2,457,306

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1992	1993	1994	1995	1996	1997	1998
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun							
26-Jun							
27-Jun							
28-Jun		12					
29-Jun		252					
30-Jun		108					
01-Jul		30					
02-Jul	0	360				276	72
03-Jul	762	576	228	3,078	5,604	1,290	1,626
04-Jul	948	990	480	4,644	28,866	1,476	768
05-Jul	678	1,236	252	3,810	63,156	1,704	1,134
06-Jul	426	1,776	480	22,038	97,320	2,370	1,536
07-Jul	924	5,838	258	55,806	51,000	9,288	6,840
08-Jul	894	137,754	120	41,676	36,660	13,500	10,170
09-Jul	942	406,152	4,830	12,288	13,512	31,380	15,114
10-Jul	834	411,066	101,970	11,664	6,834	34,230	15,222
11-Jul	798	235,200	204,678	11,358	8,370	48,090	34,056
12-Jul	3,066	66,972	207,204	17,988	6,672	49,056	54,678
13-Jul	9,426	10,998	50,076	9,768	5,292	37,080	97,848
14-Jul	65,730	7,950	24,162	7,812	5,676	43,572	163,350
15-Jul	401,778	4,776	31,284	5,850	9,606	60,876	92,286
16-Jul	529,362	8,352	63,144	23,940	57,654	21,024	27,444
17-Jul	548,964	8,256	38,490	45,906	88,614	36,096	16,746
18-Jul	348,852	8,076	38,982	278,538	66,930	24,918	18,672
19-Jul	44,154	6,588	56,484	357,996	33,444	13,254	17,556
20-Jul	38,520	21,060	88,884	222,102	25,716	23,808	14,802
21-Jul	17,322	13,872	100,134	90,858	11,262	28,134	12,318
22-Jul	8,082	5,004	19,836	22,278	13,344	25,380	15,894
23-Jul	6,156	3,966	12,942	12,546	13,158	20,874	11,334
24-Jul	16,158	3,228	8,454	6,822	10,326	24,930	16,056
25-Jul	21,426	7,374	6,330	10,374	4,530	12,918	36,346
26-Jul	58,248	5,766	3,216	13,602	3,972	13,032	81,486
27-Jul	25,002	5,946	4,668	11,316		22,662	50,856
28-Jul	18,324		13,272			13,650	39,702
29-Jul	5,916					3,528	21,510
30-Jul							16,086
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
05-Aug							
06-Aug							
07-Aug							
08-Aug							
09-Aug							
Total	2,173,692	1,389,534	1,080,858	1,304,058	667,518	618,396	890,508

Appendix A.7. Ugashik River historical daily escapement, 1957-1999.

Date	1999
20-Jun	
21-Jun	
22-Jun	
23-Jun	
24-Jun	
25-Jun	
26-Jun	
27-Jun	
28-Jun	
29-Jun	
30-Jun	
01-Jul	
02-Jul	
03-Jul	
04-Jul	
05-Jul	
06-Jul	
07-Jul	6
08-Jul	33,180
09-Jul	203,940
10-Jul	189,654
11-Jul	183,408
12-Jul	328,740
13-Jul	354,384
14-Jul	78,528
15-Jul	88,260
16-Jul	45,846
17-Jul	21,462
18-Jul	10,548
19-Jul	3,048
20-Jul	6,348
21-Jul	8,688
22-Jul	24,810
23-Jul	25,434
24-Jul	22,674
25-Jul	12,528
26-Jul	10,086
27-Jul	
28-Jul	
29-Jul	
30-Jul	
31-Jul	
01-Aug	
02-Aug	
03-Aug	
04-Aug	
05-Aug	
06-Aug	
07-Aug	
08-Aug	
09-Aug	
Total	1,651,572

Appendix A. 8. Wood River historical daily escapement, 1956-1999.

Date	1956	1957	1958	1959	1960	1961	1962
17-Jun							
18-Jun					0		
19-Jun					114		
20-Jun			825	57	192		
21-Jun	126		1,365	480	96		6
22-Jun	10	656	2,376	348	132		162
23-Jun	2,218	734	6,747	996	211		84
24-Jun	2,838	1,168	5,541	1,452	512		96
25-Jun	1,523	748	1,512	1,176	1,296	30	228
26-Jun	872	906	2,247	3,048	10,013	1,104	1,866
27-Jun	943	1,246	2,121	16,986	8,208	4,224	1,014
28-Jun	5,964	2,216	902	105,984	4,116	2,874	786
29-Jun	5,816	4,326	1,134	82,752	4,770	2,806	1,662
30-Jun	4,602	8,977	17,087	62,148	1,488	3,006	1,056
01-Jul	730	15,566	81,246	84,978	1,443	96	1,956
02-Jul	2,020	6,047	41,658	115,782	1,830	9,030	2,094
03-Jul	1,243	3,155	12,749	340,752	5,844	15,438	90,558
04-Jul	16,845	4,617	8,586	201,930	2,826	24,594	112,296
05-Jul	43,257	3,217	12,300	184,734	6,474	23,433	248,742
06-Jul	47,776	3,528	104,862	163,254	98,460	30,588	230,274
07-Jul	26,870	4,147	190,619	85,086	232,140	30,474	54,960
08-Jul	16,689	4,019	129,522	29,730	199,596	21,510	23,022
09-Jul	8,124	7,398	80,454	23,802	167,094	16,728	23,922
10-Jul	4,825	9,575	30,149	23,292	103,746	30,924	24,036
11-Jul	87,299	77,502	21,314	13,698	41,190	26,022	8,562
12-Jul	80,213	64,265	14,555	116,058	15,600	75,009	7,512
13-Jul	71,748	24,588	76,137	250,602	13,188	77,736	3,420
14-Jul	47,216	10,303	33,249	129,270	15,708	43,734	1,944
15-Jul	79,427	4,109	24,648	52,248	16,728	8,250	4,554
16-Jul	68,389	4,274	7,763	13,788	17,418	5,682	12,288
17-Jul	47,168	2,785	4,325	11,334	16,872	3,492	3,552
18-Jul	18,168	1,685	3,023	24,612	9,120	1,209	714
19-Jul	21,670	2,785	4,214	27,738	6,444	1,176	462
20-Jul	18,057	2,080	7,926	13,242	4,392	507	666
21-Jul	13,921	2,806	8,208	5,976	1,524	186	480
22-Jul	6,690	2,834	6,747	4,698	1,376	0	324
23-Jul	3,852	789	2,652	3,912	368	24	978
24-Jul	2,416	522	2,028	4,266	760	54	1,116
25-Jul	4,662	147	1,610	1,515	2,312	486	726
26-Jul	3,554	852	1,548	2,631	1,920	186	696
27-Jul	1,792	2,625	1,026	912	552	54	534
28-Jul	486	1,530	1,287	1,575		54	1,920
29-Jul	1,520		1,677	552		18	3,726
30-Jul	892		1,023	36			708
31-Jul	180		737	1,836			114
01-Aug	490		450				72
02-Aug			306				
Total	773,101	288,727	959,630	2,209,209	1,015,767	460,737	873,888

Appendix A. 8. Wood River historical daily escapement, 1956-1999.

Date	1963	1964	1965	1966	1967	1968	1969	1970
17-Jun								
18-Jun					0			4
19-Jun					114			24
20-Jun	54	24		24	60			18
21-Jun	0	390		60	18	0		12
22-Jun	30	426	60	18	144	402		0
23-Jun	684	390	42	60	108	48		54
24-Jun	2,382	324	72	72	300	6,144		222
25-Jun	2,166	594	30	60	1,410	14,064		222
26-Jun	984	1,710	96	120	1,416	2,640	0	132
27-Jun	1,386	5,328	96	96	2,070	2,508	24	270
28-Jun	5,868	8,220	270	1,290	4,614	42,126	30	390
29-Jun	6,414	8,076	174	2,154	4,212	21,138	42	648
30-Jun	5,628	8,004	426	1,542	10,704	8,856	282	618
01-Jul	4,410	1,908	510	2,106	34,470	26,934	900	1,398
02-Jul	4,512	426	486	11,172	57,192	22,596	38,652	1,182
03-Jul	3,114	480	450	30,690	29,532	49,164	92,148	2,268
04-Jul	1,248	5,538	2,922	110,082	148,020	47,058	88,482	122,418
05-Jul	220,698	94,560	33,762	251,394	76,812	75,294	68,082	116,364
06-Jul	263,328	100,830	118,356	168,966	21,174	87,960	41,826	147,930
07-Jul	15,924	31,842	173,364	233,538	29,352	41,496	53,004	200,526
08-Jul	13,464	22,386	133,224	124,044	32,304	51,648	50,838	287,340
09-Jul	17,070	166,188	91,746	62,592	22,086	62,796	67,386	75,450
10-Jul	20,634	210,990	58,878	11,886	9,786	29,442	36,348	37,218
11-Jul	63,768	275,520	18,240	20,634	6,900	11,406	15,324	35,310
12-Jul	17,724	67,656	6,960	77,496	4,728	9,942	9,984	47,364
13-Jul	13,050	23,658	4,788	47,502	5,040	9,000	10,674	42,570
14-Jul	12,822	10,878	2,364	16,284	5,538	8,034	9,912	19,020
15-Jul	5,340	9,864	7,692	9,078	1,740	5,700	3,378	10,278
16-Jul	4,134	4,008	5,646	6,132	1,656	7,476	2,898	3,744
17-Jul	4,320	4,974	4,056	6,492	1,476	3,036	3,666	2,790
18-Jul	2,250	2,508	5,724	5,358	684	978	2,682	1,488
19-Jul	1,830	1,890	2,796	2,382	120	690	2,400	1,338
20-Jul	876	1,710	726	2,208	126	288	1,596	1,026
21-Jul	1,536	1,152	654	1,044	288	324	1,074	978
22-Jul	1,200	966	396	972	132	126	1,266	672
23-Jul	1,044	480	84	528	456	30	570	426
24-Jul	492	498	66	0	474		486	186
25-Jul	306	396		558	384		252	66
26-Jul	246	222		48	108		102	
27-Jul	126	108			24		30	
28-Jul	102	990						
29-Jul	54							
30-Jul	180							
31-Jul	6							
01-Aug								
02-Aug								
Total	721,350	1,076,088	675,156	1,208,658	515,598	649,344	604,338	1,161,918

Appendix A. 8. Wood River historical daily escapement, 1956-1999.

Date	1971	1972	1973	1974	1975	1976	1977	1978
17-Jun								
18-Jun								
19-Jun					0			300
20-Jun			36	132	0	12	0	918
21-Jun		18	594	858	0	0	42	30
22-Jun		0	480	354	0	0	354	144
23-Jun		0	66	1,188	192	0	774	6,630
24-Jun		0	42	774	192	144	204	8,490
25-Jun	18	78	30	2,112	354	822	2,778	11,334
26-Jun	66	774	78	1,470	246	432	4,230	5,616
27-Jun	162	942	510	1,110	198	120	3,474	4,536
28-Jun	96	306	3,468	1,422	450	642	8,400	13,626
29-Jun	186	72	3,012	5,172	3,402	570	39,066	167,796
30-Jun	1,332	18	8,862	109,668	6,684	276	61,734	107,154
01-Jul	676	96	32,442	162,744	2,850	90	49,530	108,018
02-Jul	654	36	8,046	271,206	14,442	102	20,886	145,440
03-Jul	204	72	8,514	275,082	11,976	276	33,882	202,716
04-Jul	588	48	6,210	340,332	2,556	22,038	73,062	433,260
05-Jul	450	66	2,970	187,026	2,004	119,832	64,782	389,172
06-Jul	834	162	7,080	123,630	516	88,680	27,912	85,020
07-Jul	8,076	168	5,034	53,106	34,470	86,064	38,280	100,974
08-Jul	20,340	3,366	36,586	36,378	213,438	26,670	24,732	142,284
09-Jul	58,836	83,784	86,208	27,354	307,632	23,250	24,822	101,328
10-Jul	42,030	205,878	47,844	19,494	228,132	93,792	23,538	67,710
11-Jul	74,394	76,268	34,158	17,736	150,246	132,282	7,170	33,072
12-Jul	133,584	18,222	15,954	12,072	126,348	99,432	4,920	28,044
13-Jul	57,684	16,800	9,876	5,562	65,136	40,512	22,494	25,452
14-Jul	93,948	10,104	4,680	6,084	20,802	16,962	13,110	11,838
15-Jul	129,264	5,982	2,370	7,698	19,002	12,012	2,838	7,950
16-Jul	104,688	2,862	1,908	5,748	19,500	9,336	1,404	4,260
17-Jul	46,428	3,222	1,884	6,150	13,440	12,228	1,590	9,462
18-Jul	18,522	750	732	5,442	9,960	9,774	2,052	19,698
19-Jul	12,180	606	612	2,784	4,320	7,002	1,434	6,042
20-Jul	6,516	672	498	1,368	3,264	4,584	1,056	5,838
21-Jul	6,132	168	228	3,936	3,168	5,010	1,068	5,766
22-Jul	7,746	72	84	594	2,178	3,084	210	3,504
23-Jul	12,750		246	1,656	1,806	474		3,336
24-Jul	5,472		132	2,064	894	504		480
25-Jul	3,306			2,904	318			
26-Jul	1,206			1,134				
27-Jul	1,116			3,012				
28-Jul	702			1,260				
29-Jul	900			918				
30-Jul	216			102				
31-Jul								
01-Aug								
02-Aug								
Total	851,202	430,602	330,438	1,708,704	1,270,116	816,996	561,828	2,266,020

Appendix A. 8. Wood River historical daily escapement, 1956-1999.

Date	1979	1980	1981	1982	1983	1984	1985
17-Jun					0		
18-Jun		108	30	0	0		0
19-Jun	180	0	258	0	0		0
20-Jun	570	312	1,110	0	618		0
21-Jun	330	450	1,062	750	1,602		0
22-Jun	228	132	4,530	2,718	870	372	0
23-Jun	78	426	7,002	2,304	1,302	1,896	0
24-Jun	276	54	1,752	696	2,256	3,084	0
25-Jun	55,026	174	222	864	756	55,242	0
26-Jun	245,730	48	180	1,968	16,272	55,710	0
27-Jun	159,702	522	690	16,062	65,952	20,376	0
28-Jun	18,462	906	1,716	33,492	42,618	5,016	0
29-Jun	12,480	24,810	10,032	43,494	36,174	4,506	0
30-Jun	9,348	120,912	15,210	94,734	13,788	33,822	2,754
01-Jul	263,688	175,638	59,316	100,752	23,190	64,194	78,294
02-Jul	529,596	341,214	24,720	68,298	10,026	72,690	85,764
03-Jul	39,468	415,668	20,022	65,544	299,970	55,440	86,634
04-Jul	8,502	460,722	137,712	126,222	599,454	60,486	98,082
05-Jul	18,960	198,684	308,028	129,912	94,944	40,554	29,448
06-Jul	166,998	141,096	214,920	44,322	14,838	136,950	19,584
07-Jul	115,812	162,906	70,818	41,154	13,266	91,974	20,922
08-Jul	18,036	230,490	69,246	33,882	13,614	83,994	67,242
09-Jul	5,952	246,156	55,080	16,470	20,250	83,922	84,354
10-Jul	5,046	95,850	67,056	12,306	5,508	51,378	48,594
11-Jul	3,900	46,992	43,752	18,948	3,222	29,784	24,276
12-Jul	7,704	119,424	23,550	17,034	1,956	10,494	30,774
13-Jul	5,406	76,950	19,710	15,288	2,352	8,172	20,472
14-Jul	4,320	31,950	14,058	22,200	34,278	3,954	88,914
15-Jul	5,190	29,628	15,630	14,352	14,730	1,800	92,334
16-Jul	4,992	25,416	14,394	10,536	11,106	3,834	34,920
17-Jul	372	12,462	8,664	13,206	6,666	3,936	11,706
18-Jul		7,386	5,334	12,600	2,838	1,872	4,284
19-Jul		1,554	8,382	7,782	3,720	792	3,846
20-Jul			7,974	5,064	1,890	1,680	2,322
21-Jul			1,158	3,420	804	2,052	2,040
22-Jul				96	138	2,928	1,074
23-Jul						3,618	366
24-Jul						4,302	
25-Jul						1,170	
26-Jul						732	
27-Jul						66	
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
Total	1,705,602	2,968,620	1,231,920	976,470	1,360,350	1,002,792	939,000

Appendix A. 8. Wood River historical daily escapement, 1956-1999.

Date	1986	1987	1988	1989	1990	1991	1992
17-Jun							
18-Jun	0					168	6
19-Jun	0					84	186
20-Jun	0				72	90	1,182
21-Jun	0			378	6	246	1,458
22-Jun	0			690	1,770	90	432
23-Jun	0		18	5,400	1,554	918	894
24-Jun	174	1,620	1,098	14,502	1,032	5,262	1,938
25-Jun	1,014	6,546	9,744	23,484	198	14,136	2,082
26-Jun	444	3,702	28,320	23,190	366	4,164	16,908
27-Jun	648	5,382	19,566	24,852	186	2,580	73,056
28-Jun	414	20,304	21,522	9,504	702	14,778	34,164
29-Jun	330	86,172	14,142	4,230	1,590	18,594	22,500
30-Jun	756	217,668	2,610	89,466	5,976	9,360	11,016
01-Jul	4,860	196,200	1,362	102,918	24,336	53,478	20,148
02-Jul	11,664	117,156	2,472	190,314	81,840	46,158	16,794
03-Jul	6,984	68,058	36,372	233,634	102,726	410,964	16,152
04-Jul	28,062	19,626	107,922	95,556	50,046	252,624	28,440
05-Jul	36,246	17,790	45,564	28,230	11,544	58,338	114,642
06-Jul	37,104	16,008	14,772	65,592	131,622	18,072	122,232
07-Jul	46,620	54,066	15,678	64,608	361,104	16,398	67,416
08-Jul	34,050	198,516	20,832	46,338	126,630	10,914	52,692
09-Jul	51,084	101,814	64,206	21,636	23,898	15,858	41,832
10-Jul	112,446	30,798	82,812	17,730	25,830	17,004	96,048
11-Jul	135,834	19,878	164,610	16,320	21,732	21,258	192,552
12-Jul	126,936	16,218	161,562	17,418	29,628	20,550	153,618
13-Jul	70,194	16,266	23,622	21,960	26,508	20,070	72,540
14-Jul	29,622	27,798	3,732	25,644	13,326	18,972	38,586
15-Jul	19,524	24,540	2,268	14,514	7,650	12,264	24,342
16-Jul	19,650	14,808	4,260	6,276	9,042	11,976	14,406
17-Jul	9,030	16,506	10,308	8,484	3,486	28,200	12,462
18-Jul	7,134	13,524	4,890	8,280	2,298	21,630	5,496
19-Jul	3,240	7,524	1,326	3,948	1,740	10,548	7,008
20-Jul	3,930	7,386	1,188	1,314	1,002	8,844	6,930
21-Jul	3,138	6,768				6,834	6,054
22-Jul	4,602	3,798				4,272	6,780
23-Jul	4,734	732				4,224	3,252
24-Jul	8,184						
25-Jul							
26-Jul							
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
Total	818,652	1,337,172	866,778	1,186,410	1,069,368	1,159,578	1,284,870

Appendix A. 8. Wood River historical daily escapement, 1956-1999.

Date	1993	1994	1995	1996	1997	1998	1999
17-Jun							
18-Jun							
19-Jun		0					
20-Jun	72	0					
21-Jun	72	0	126	9,090			
22-Jun	132	1,326	450	4,716	7,686		
23-Jun	40,446	672	600	7,698	8,904	3,558	186
24-Jun	37,110	228	2,136	32,364	13,854	3,864	5,442
25-Jun	46,548	1,470	16,602	41,010	27,798	13,650	2,676
26-Jun	34,482	3,150	94,710	26,616	28,392	25,068	1,860
27-Jun	81,168	3,444	104,196	38,232	30,618	16,428	10,086
28-Jun	84,648	1,902	23,502	32,778	57,126	17,826	15,180
29-Jun	65,706	1,332	104,904	13,392	52,632	31,170	10,218
30-Jun	66,270	1,008	99,630	47,472	51,660	24,960	27,972
01-Jul	40,320	6,078	36,390	63,186	50,526	18,558	17,592
02-Jul	83,922	37,530	27,990	111,036	91,056	41,856	87,390
03-Jul	183,540	65,616	20,454	134,370	127,134	95,130	347,124
04-Jul	97,344	62,094	12,690	164,094	127,086	520,476	214,188
05-Jul	68,406	41,190	40,284	107,130	68,826	512,370	234,300
06-Jul	51,414	64,890	56,040	122,814	101,616	61,038	107,280
07-Jul	34,998	34,182	238,458	138,006	71,502	99,432	78,492
08-Jul	24,096	21,102	240,792	108,468	73,014	108,276	47,634
09-Jul	12,582	301,710	145,896	50,706	156,120	45,804	28,314
10-Jul	8,514	346,830	47,496	52,104	35,268	27,204	23,130
11-Jul	11,880	113,472	29,226	75,606	66,618	13,800	96,810
12-Jul	18,714	35,484	22,488	60,342	66,366	11,430	33,366
13-Jul	10,722	13,812	22,512	36,138	60,072	11,082	22,950
14-Jul	19,440	15,018	13,722	23,160	30,630	8,232	30,810
15-Jul	9,390	13,020	14,346	15,912	29,136	12,588	11,034
16-Jul	9,204	64,572	29,352	11,544	15,948	10,902	14,550
17-Jul	15,972	73,746	14,310	10,074	12,228	5,598	10,410
18-Jul	11,202	39,300	7,332	37,692	15,276	3,492	8,016
19-Jul	4,206	18,426	5,682	19,092	11,310	3,156	4,008
20-Jul	1,338	16,170	4,284	22,488	8,466	2,916	6,264
21-Jul	2,268	17,436	3,798	15,372	5,772	2,100	5,748
22-Jul		28,884	1,764	16,896	9,756	2,628	6,348
23-Jul		14,796				1,176	3,048
24-Jul		12,000					
25-Jul							
26-Jul							
27-Jul							
28-Jul							
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
Total	1,176,054	1,471,890	1,482,162	1,649,598	1,512,396	1,755,768	1,512,426

Appendix B

Historical escapement data for previous Sockeye salmon

Counting towers no longer operating in Bristol Bay

Appendix B. 1. Branch River historical daily sockeye escapement, 1957-1976.

Date	1957	1958	1959	1960	1961	1962	1963
18-Jun							
19-Jun							
20-Jun							
21-Jun							
22-Jun							
23-Jun							
24-Jun							
25-Jun				0			
26-Jun				6			
27-Jun				0	735		
28-Jun			375	6	2,214		
29-Jun	66		1,128	0	8,295		144
30-Jun	694		1,143	54	4,968	150	4,038
01-Jul	1,521	234	258	2,652	276	444	3,576
02-Jul	1,586	234	870	72,018	150	5,340	8,970
03-Jul	430	426	1,350	120,792	3,102	3,252	5,814
04-Jul	1,266	48	27,198	37,926	21,402	3,648	5,304
05-Jul	203	0	68,544	13,170	11,364	4,788	20,556
06-Jul	997	1,044	68,650	50,700	5,292	27,870	37,086
07-Jul	2,640	4,320	82,179	162,516	588	24,060	29,658
08-Jul	1,422	17,646	25,017	199,386	324	11,994	12,390
09-Jul	3,378	23,682	19,455	185,598	216	2,718	3,426
10-Jul	10,842	9,444	28,791	134,592	372	1,752	17,964
11-Jul	18,174	1,830	3,174	81,912	462	672	17,376
12-Jul	28,470	1,236	53,655	32,910	1,770	786	11,328
13-Jul	14,205	390	96,355	22,860	7,998	252	7,578
14-Jul	4,912	5,484	124,545	15,582	10,512	72	4,866
15-Jul	4,668	19,146	112,694	23,706	2,880	168	2,130
16-Jul	7,090	4,518	24,462	45,150	804	900	636
17-Jul	3,114	1,854	6,724	20,610	144	864	1,560
18-Jul	1,356	678	26,973	8,598	906	606	2,358
19-Jul	5,562	636	20,553	3,204	1,344	222	2,256
20-Jul	3,384	168	10,443	1,668	408	24	1,944
21-Jul	1,050	918	5,040	2,682	474	6	414
22-Jul	1,228	444	4,365	1,182	522	36	282
23-Jul	1,424	66	1,623	570	840	6	540
24-Jul	3,846	36	759	276	438		588
25-Jul	1,140	114	2,331	180	714		258
26-Jul	1,104	12	4,404	12	144		222
27-Jul	372	0	1,884	12	48		66
28-Jul	204	18	141		60		6
29-Jul	247	24	216		144		
30-Jul			132		126		
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
Total	126,595	94,650	825,431	1,240,530	90,036	90,630	203,334

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Appendix B. 1. Branch River historical daily sockeye escapement, 1957-1976.

Date	1964	1965	1966	1967	1968	1969	1970
18-Jun					0		
19-Jun					12		
20-Jun					0		
21-Jun					0	0	
22-Jun				0	0	0	
23-Jun				222	0	0	
24-Jun				114	0	0	
25-Jun				144	0	0	
26-Jun		0		1,410	6	0	
27-Jun		0		2,244	0	0	0
28-Jun		0	0	2,640	2,724	0	36
29-Jun		0	0	18,480	22,764	0	282
30-Jun		120	0	24,252	6,654	2,748	3,024
01-Jul		888	0	49,506	3,738	19,998	8,346
02-Jul	156	3,912	0	66,474	15,396	16,422	11,598
03-Jul	48	5,088	0	8,220	13,008	21,594	23,196
04-Jul	18	8,568	852	16,566	17,496	31,056	26,052
05-Jul	1,032	16,056	4,578	9,108	25,194	26,502	16,872
06-Jul	30,504	31,206	11,802	14,484	17,052	25,932	19,122
07-Jul	45,162	29,358	22,692	10,332	17,160	24,582	13,524
08-Jul	100,758	15,294	43,104	9,030	8,742	9,096	14,856
09-Jul	7,548	27,582	38,580	6,978	2,844	1,884	12,966
10-Jul	5,322	15,882	12,246	3,588	4,524	756	7,332
11-Jul	23,286	11,292	2,292	1,164	21,084	282	4,104
12-Jul	13,836	4,260	3,210	5,616	5,790	546	3,414
13-Jul	9,660	762	8,742	17,292	1,530	420	4,644
14-Jul	2,400	864	4,614	4,722	1,620	330	3,336
15-Jul	2,232	300	2,982	1,746	2,154	336	1,158
16-Jul	846	1,350	3,372	1,434	2,148	6	444
17-Jul	1,710	1,230	1,788	1,452	1,368		738
18-Jul	744	876	4,698	2,160	648		846
19-Jul	894	96	2,058	1,434	114		1,068
20-Jul	1,068	36	1,134	618	36		66
21-Jul	882		2,268	2,634	66		36
22-Jul	234		1,098	1,716			
23-Jul	210		1,536	2,070			
24-Jul	60		690	6,204			
25-Jul	78			1,236			
26-Jul	12			114			
27-Jul				30			
28-Jul				12			
29-Jul							
30-Jul							
31-Jul							
01-Aug							
02-Aug							
03-Aug							
04-Aug							
Total	248,700	175,020	174,336	295,224	193,872	182,490	177,060

Appendix B. 1. Branch River historical daily sockeye escapement, 1957-1976.

Date	1971	1972	1973	1974	1975	1976
18-Jun						
19-Jun						
20-Jun			0			
21-Jun			6			
22-Jun			0			
23-Jun			0			
24-Jun			0		0	
25-Jun	0		0		0	
26-Jun	6	0	0		6	
27-Jun	0	0	0	6	12	
28-Jun	0	0	0	132	12	
29-Jun	0	0	6	2,514	12	
30-Jun	0	0	0	11,502	0	0
01-Jul	0	0	6	24,474	0	0
02-Jul	0	0	0	30,336	18	12
03-Jul	0	0	24	27,672	540	6
04-Jul	0	0	0	28,080	1,912	6
05-Jul	18	0	24	21,852	3,282	18
06-Jul	282	1,758	744	23,112	11,904	20,148
07-Jul	4,758	44,874	3,978	19,800	15,042	5,790
08-Jul	5,136	43,188	11,826	9,996	17,016	1,026
09-Jul	21,228	5,856	11,100	4,584	22,980	1,308
10-Jul	28,146	23,544	5,880	4,998	12,882	14,208
11-Jul	29,010	14,340	468	3,186	4,902	23,994
12-Jul	9,594	7,410	474	870	5,352	10,590
13-Jul	12,252	5,778	270	852	2,202	3,222
14-Jul	13,290	2,022		792	1,476	1,020
15-Jul	24,516	960		90	684	414
16-Jul	21,216	408			156	60
17-Jul	6,744	228			90	
18-Jul	1,398	576				
19-Jul	1,326	180				
20-Jul	1,038	66				
21-Jul	1,032					
22-Jul	726					
23-Jul	1,218					
24-Jul	1,752					
25-Jul	1,476					
26-Jul	468					
27-Jul	408					
28-Jul	264					
29-Jul						
30-Jul						
31-Jul						
01-Aug						
02-Aug						
03-Aug						
04-Aug						
Total	187,302	151,188	34,806	214,848	100,480	81,822

Appendix B.2. Branch River historical daily chinook salmon escapement, 1966-1976.

Date	1966	1967	1968	1969	1970	1971	1972	1973
20-Jun								
21-Jun				0				
22-Jun				0				
23-Jun				0				
24-Jun				0				
25-Jun				0		0		
26-Jun				0		0	0	
27-Jun				0	0	0	0	
28-Jun				0	0	0	0	
29-Jun				0	0	0	0	
30-Jun				0	0	0	0	NO
01-Jul		36		0	0	0	0	DATA
02-Jul		6		0	0	0	0	AVAILABLE
03-Jul		0	6	0	12	0	0	
04-Jul	6	0	18	0	18	0	0	
05-Jul	48	0	12	0	0	0	0	
06-Jul	6	0	18	0	6	6	0	
07-Jul	12	0	0	0	0	0	6	
08-Jul	90	0	0	0	0	6	0	
09-Jul	6	0	0	0	6	0	0	
10-Jul	6	78	0	0	0	0	0	
11-Jul	6	78	0	0	0	18	0	
12-Jul	30	342	0	0	0	6	0	
13-Jul	18	792	0	0	0	0	0	
14-Jul	18	126	12	6	6	0	0	
15-Jul	12	24	0	0	6	0	0	
16-Jul	12	6	0	0	6	0	0	
17-Jul	54	12	6		0	12	0	
18-Jul	42	24	294		18	18	18	
19-Jul	120	18	72		66	24	6	
20-Jul	252	12	66		54	6	6	
21-Jul	390	36	78		102	12		
22-Jul	282	246				36		
23-Jul	396	198				18		
24-Jul		510				12		
25-Jul		192				30		
26-Jul		66				24		
27-Jul		186				48		
28-Jul		534				6		
29-Jul								
30-Jul								
31-Jul								
01-Aug								
02-Aug								
03-Aug								
04-Aug								
Total	1,806	3,522	582	6	300	282	36	

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Appendix B.2. Branch River historical daily chinook salmon escapement, 1966-1976.

Date	1974	1975	1976
20-Jun			
21-Jun			
22-Jun			
23-Jun			
24-Jun			
25-Jun			
26-Jun	0		
27-Jun	0		
28-Jun	0		
29-Jun	0		
30-Jun	0	NO	0
01-Jul	0	DATA	6
02-Jul	0	AVAILABLE	0
03-Jul	0		0
04-Jul	6		0
05-Jul	0		0
06-Jul	12		0
07-Jul	12		0
08-Jul	6		6
09-Jul	30		0
10-Jul	0		0
11-Jul	6		0
12-Jul	0		0
13-Jul	12		0
14-Jul	6		12
15-Jul	6		6
16-Jul			234
17-Jul			
18-Jul			
19-Jul			
20-Jul			
21-Jul			
22-Jul			
23-Jul			
24-Jul			
25-Jul			
26-Jul			
27-Jul			
28-Jul			
29-Jul			
30-Jul			
31-Jul			
01-Aug			
02-Aug			
03-Aug			
04-Aug			
Total	96		264

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Appendix B.3. Snake River historical daily escapement, 1960-1973.

Date	1960	1961	1962	1963	1964	1973 [a]
20-Jun						
21-Jun						
22-Jun						
23-Jun						
24-Jun						
25-Jun			0			
26-Jun	0		0		0	
27-Jun	81	0	0		0	
28-Jun	75	0	0		0	
29-Jun	0	30	0		0	
30-Jun	54	0	8	136	0	
01-Jul	0	0	4	40	0	
02-Jul	24	6	0	28	0	
03-Jul	0	0	0	2,548	0	
04-Jul	52	0	0	2,044	0	
05-Jul	0	0	36	728	0	
06-Jul	144	0	80	1,732	0	
07-Jul	336	0	40	6,796	1,492	14
08-Jul	1,124	0	40	11,980	1,224	17
09-Jul	2,824	312	424	3,328	144	1
10-Jul	3,140	32	580	1,580	460	5
11-Jul	2,368	8	24	1,000	672	13
12-Jul	1,408	44	60	484	1,936	5
13-Jul	1,024	760	84	1,504	2,060	0
14-Jul	840	1,792	60	1,720	524	52
15-Jul	472	584	8	408	1,948	18
16-Jul	564	464	48	68	892	248
17-Jul	236	192	72	84	24	69
18-Jul	32	308	52	1,044	468	63
19-Jul	924	112	36	56	364	123
20-Jul	500	108	32	228	120	50
21-Jul	264	0	12	216	20	32
22-Jul	84	0	20	100	56	8
23-Jul	20	28	32	40	20	11
24-Jul	8	12	8	20	12	42
25-Jul		8	0	12		0
26-Jul		4	0			0
27-Jul		52				49
28-Jul						32
29-Jul						37
30-Jul						0
31-Jul						0
01-Aug						6
02-Aug						22
03-Aug						4
04-Aug						9
05-Aug						1
Total	16,598	4,856	1,760	37,924	12,436	931

a Project became a weir for rehabilitation project.

Appendix C

1999 Comparative eastside tower counts from

Sockeye salmon counting towers in Bristol Bay

Appendix C. 1999 Eastside tower comparison counts[a]

KVICHAK TOWER	CONTROL	CREW 1	CONTROL	CREW 2	CONTROL	CREW 3
	2,720	2,350	2,310	2,240	4,500	5,040
	3,130	3,710	2,470	2,830	3,890	3,300
	4,110	4,400	2,300	2,060	822	820
	1,030	973			700	653
	1,080	1,110			960	1,016
	305	313			256	257
	1,490	1,740				
	1,500	1,610				
Total	15,365	16,206	7,080	7,130	11,128	11,086
Control/Crew	0.95		0.99		1.00	

NAKNEK TOWER	CONTROL	CREW 1	CONTROL	CREW 2	CONTROL	CREW 3
	37	31	16	17		
	14	12	4	3		
	79	65	31	26		
	87	47	11	12		
	22	21	667	618		
	18	13	2,310	2,465		
	14	13				
	15	15				
	31	24				
	1	1				
	860	800				
	2,150	2,100				
Total	3,328	3,142	3,039	3,141		
Control/Crew	1.06		0.97			

EGEGIK TOWER	CONTROL	CREW 1	CONTROL	CREW 2	CONTROL	CREW 3
	400	475	225	300	(570)	(490)
	946	1,020	660	545	340	250
	340	255	175	160	(3,020)	(3,500)
	1,040	1,025	790	745	180	175
	385	376	1,140	1,045		
	1,560	1,510	261	285		
	90	115	115	185		
			87	110		
			215	211		
			91	95		
			227	236		
			705	634		
			325	322		
			176	180		
			520	547		
			125	135		
Total	4,761	4,776	5,837	5,735	(3,070)	(3,565)
Control/Crew	1.00		1.02		0.86	

UGASHIK TOWER	CONTROL	CREW 1	CONTROL	CREW 2	CONTROL	CREW 3
	-	-	965	904	910	740
	1,025	837	52	50	945	760
	498	503	2,560	2,005		
	1,610	1,620				
Total	3,133	2,960	3,577	2,959	1,855	1,500
Control/Crew	1.06		1.21		1.24	

[a] Data in boxes collected during fair or poor conditions

Apppendix D

Historic tower literature

U. S. Department of the Interior
Fish and Wildlife Service
Administration of Alaska Commercial Fisheries

WESTERN ALASKA SALMON INVESTIGATIONS

Field Report on the Evaluation of Towers for Counting Migrating Red Salmon in Bristol Bay, 1956

Background

A more complete count of the annual Bristol Bay red salmon spawning escapement is required if management practices are to be refined and improved.

At present, the Naknek, Egegik and Ugashik escapements are enumerated by weirs operated by the Fish and Wildlife Service. In addition, the Fisheries Research Institute is developing enumeration techniques on the Wood and Kvichak systems by counting from towers. The Alagnak, Togiak, Igushik and main Nushagak Rivers also support substantial red salmon spawning escapements which should be enumerated. Also, possibly the Dog Salmon River population is large enough to warrant censusing.

Weirs are too costly, are impractical in the larger rivers and may interfere unduly with the migration of the salmon. Consequently, during 1956, using funds from the Saltonstall-Kennedy Act, the Fish and Wildlife Service made a thorough comparison of weir counts and tower counts on the Egegik River.

Description of the Area

The Egegik River is about 25 miles in length from its source at the outlet of Becharof Lake to the mouth where it enters Bristol Bay. During the summer months of 1956, the mean river flow about one mile below the outlet was about 7,000 c.f.s. Tidal influence is noticeable along the entire river below the relatively swift rapids of the uppermost mile. The Fish and Wildlife Service counting weir site is located about 2.5 miles below the outlet of the lake and has about a one-foot mean tidal range. Two large fresh water lagoons exist a short distance below the weir site, and according to some observers, each year adult red salmon characteristically remain in the lagoons several days before continuing their migration up into the lake. The river banks and surrounding area are free from trees or other wind-sheltering growth. Figure 1 is a map of the Egegik River depicting the weir site, tower sites, and location of the lagoons.

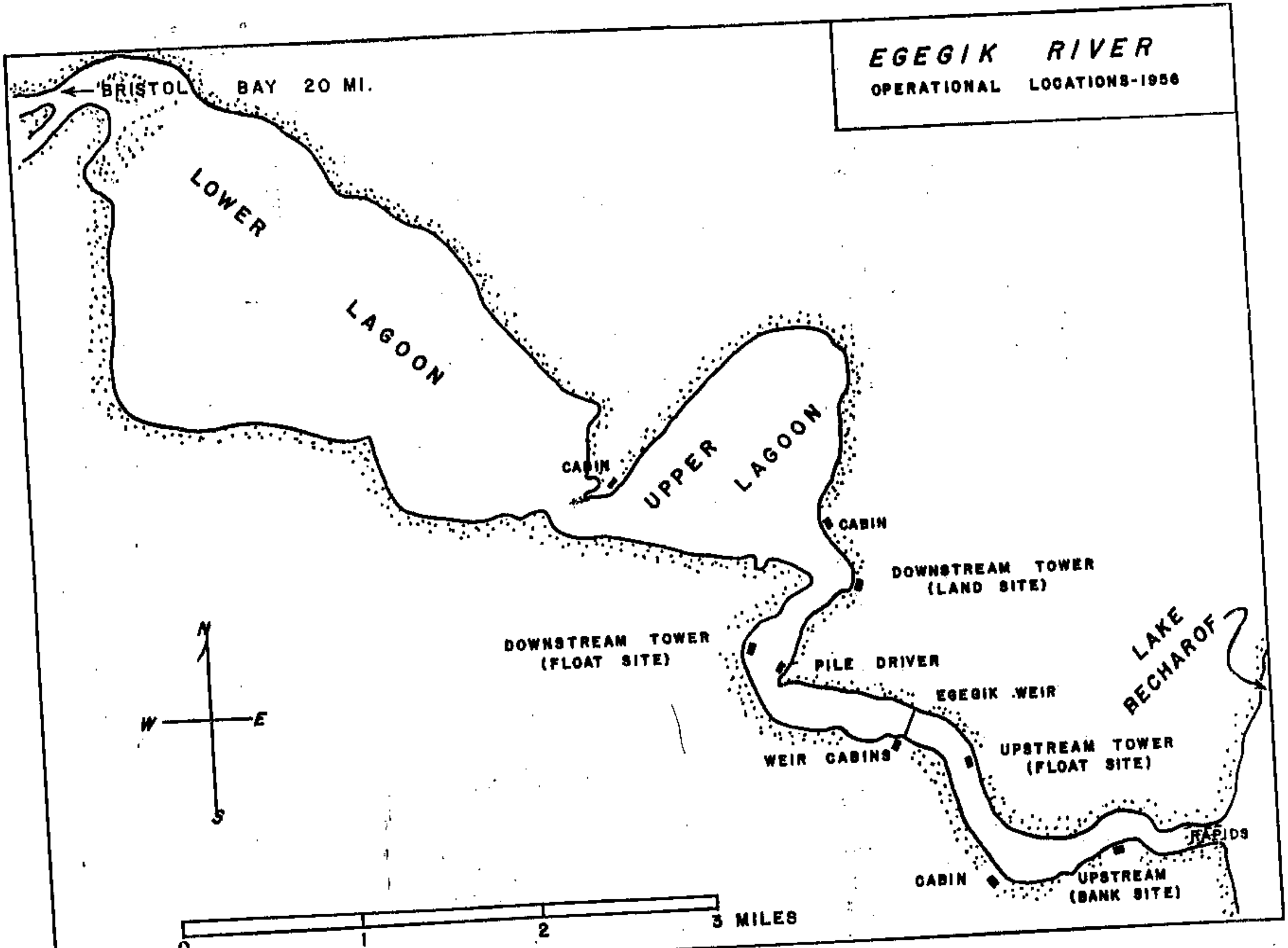

Fig. 1 Map of Egegik River Area

Objectives

The objectives of the 1956 Egegik tower counting study were fourfold: (1) Become familiar with the problems involved in the installation and operation of counting towers; (2) Learn as much as possible concerning the factors influencing the behavior of migrating red salmon, especially the effects of the weir; (3) Determine the relative completeness of tower counts and the factors which equate them to the weir counts; and (4) Determine the minimum counting effort required to provide the desired degree of accuracy in estimating the daily number of salmon passing the counting sites.

Operations

A crew of six seasonal employees arrived at Egegik June 14 under direct supervision of Charles Weaver. Weaver transferred to another project June 29 and Charles Goldman was placed in immediate supervision at that time. On August 7, the studies were terminated and the crew departed Egegik.

Four towers were employed to observe the migration--two above the weir and two below. In addition, limited observation of fish behavior was achieved from the pile driver below the weir and from a high bank above the weir. Figure 2 pictorially presents a counting tower.

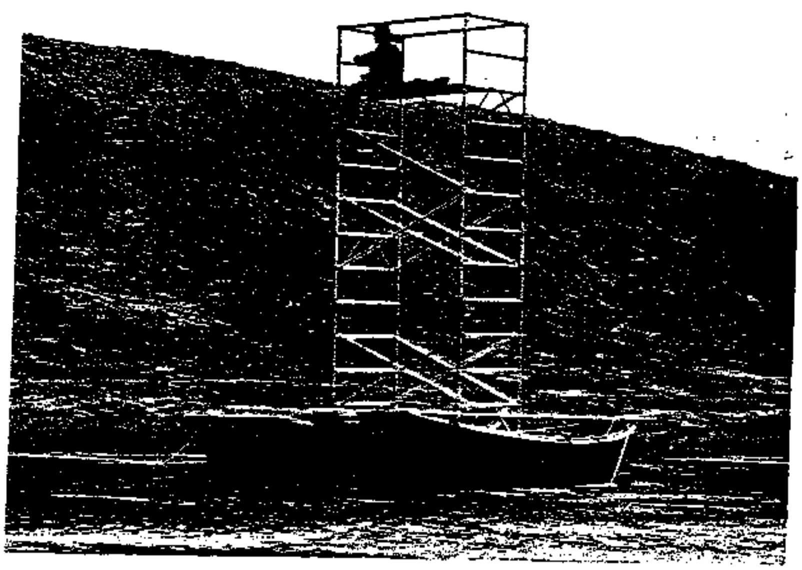

Fig. 2 Upstream Counting Tower

Counting was conducted from towers located on each bank above and below the weir in shifts of four to six hours for each counter, depending on the availability of personnel. A counter normally alternated counting and resting each 15 minutes during his shift. The downstream towers were manned during daylight hours, but the upstream towers generally were manned only after daily counting began at the weir, and subsequently until darkness.

Counts at the towers were obtained with Veeder-Root hand tallies and recorded at intervals in field books carried by each man.

The weir is about 700 feet in length and is of pile construction with wooden pickets framed between the piling on 6X6" stringers (Fig. 3). Chicken wire and sand bags seal the bottom of the pickets on the shifting sand bottom. A crew of six men using a pile driver, a motor launch and a scow required about three weeks to construct the weir. It was considered fish tight on July 7 and counting began. Two of the crew operated the weir until August 19, when they were reinforced by three additional men to remove the weir.

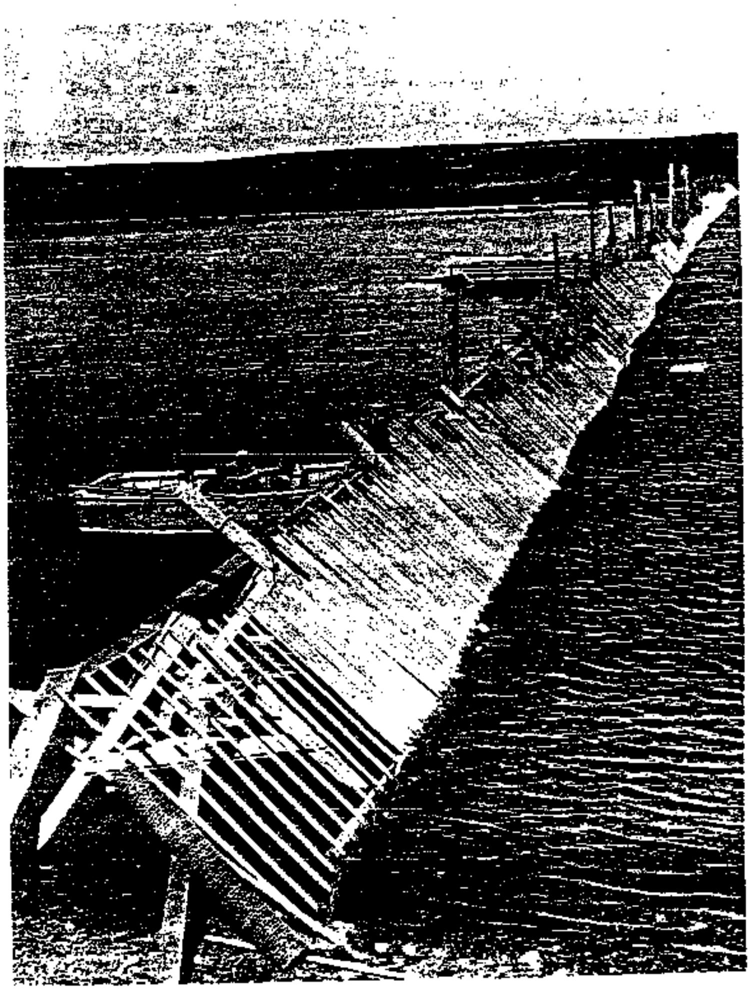

Fig. 3 Egegik Weir, 1956

During the normal operation, when few fish were moving, the weir gates were kept closed until an accumulation of fish was evident below the weir. A gate or two was then opened and fish allowed to pass until the accumulation was reduced. In mid season during the period of heaviest migration, four gates were opened simultaneously and counting occurred at each gate for 20 minutes out of each hour. Counts were then converted to hourly estimates of fish passing through the weir. Some variation in the counting technique occurred.

Problems Involving Installation and Operation of Counting Towers

It was found that the selection of adequate tower sites depended primarily on four factors: (1) it must be where the fish migrate in a single path and all can be distinctly observed and counted; (2) it should be in the lee of sheltering river banks where surface disturbances caused by the wind and current are at a minimum; (3) the river bed should be light-colored and uniform in order to silhouette individual fish; and (4) that the site be so situated that low morning and evening sun causes minimum glare for the observers.

by placing on the stream bed 4X8' panels constructed of reinforcing steel and painted hardware cloth.

Towers erected on a scow, or on two set net skiffs lashed together were found to increase the mobility of the observer and also allowed the counter to take advantage of water depth and light conditions by looking either towards or away from shore.

Poor visibility due to the wind action was a major problem. Some work was done on developing floating equipment that would damp surface ripples caused by wind and current action and improve the visibility during windy and overcast days. It was observed that floating logs athwart the stream and anchored about 40 feet upwind from the observation point provided the best damping effect. Transparent sheet plastic material was tried in various ways but proved unsatisfactory. More research is needed along this line.

It was learned that although upstream fish movement decreased during the late evening and dark hours, some nocturnal movement did take place. Further research is needed on whether it is necessary to obtain night counts during future counting.

Polaroid glasses for observers were found to increase visibility beneath the surface in virtually all instances of daylight counting, and they are necessary equipment for counting from towers.

Enclosed shelters on the counting towers are necessary. It was found that during 4-hour or 6-hour counting shifts on windy and rainy days, counters tended to become chilled and the resulting discomfort probably reduced counting efficiency.

Skiffs equipped with outboard motors were used to go to and from the towers. Lack of familiarity with the boulder strewn river bed resulted in a serious maintenance problem with the motors. Several times it was impossible to maintain counting schedules because outboards were not in operating condition.

Factors Influencing Behavior of Migrating Red Salmon and Effect of the Weir

It was observed that the fish closely followed the contour of each bank of the river in water about three to six feet deep and rarely more than thirty feet from the shore. (Fig. 4) The migrations occurred in a narrow band of about four to ten fish swimming abreast and appearing in a steady stream. The right bank carried by far the greater number of fish, but sporadically, greater numbers appeared to follow the left bank. There appeared to be little, if any, crossing from bank to bank once the fish had passed the weir.

Normally the red salmon did not diverge from their migration path as they passed the towers. However, in one instance it was noted that all fish uniformly swerved out to avoid passing beneath a red bottom skiff that had been moved over the migration path as a wind break. In another instance, it was noted that all fish swerved out to avoid passing close to a white boat hull abandoned in the water near the migration path. It was noted that moored logs that bobbed in the current caused fish to shy into deeper water in an apparent alarm reaction. A change in mooring lines stabilized the logs and corrected this condition. Manila lines extending into the migration path appeared to have little effect on the upstream movement if the lines were not undulating in the current.

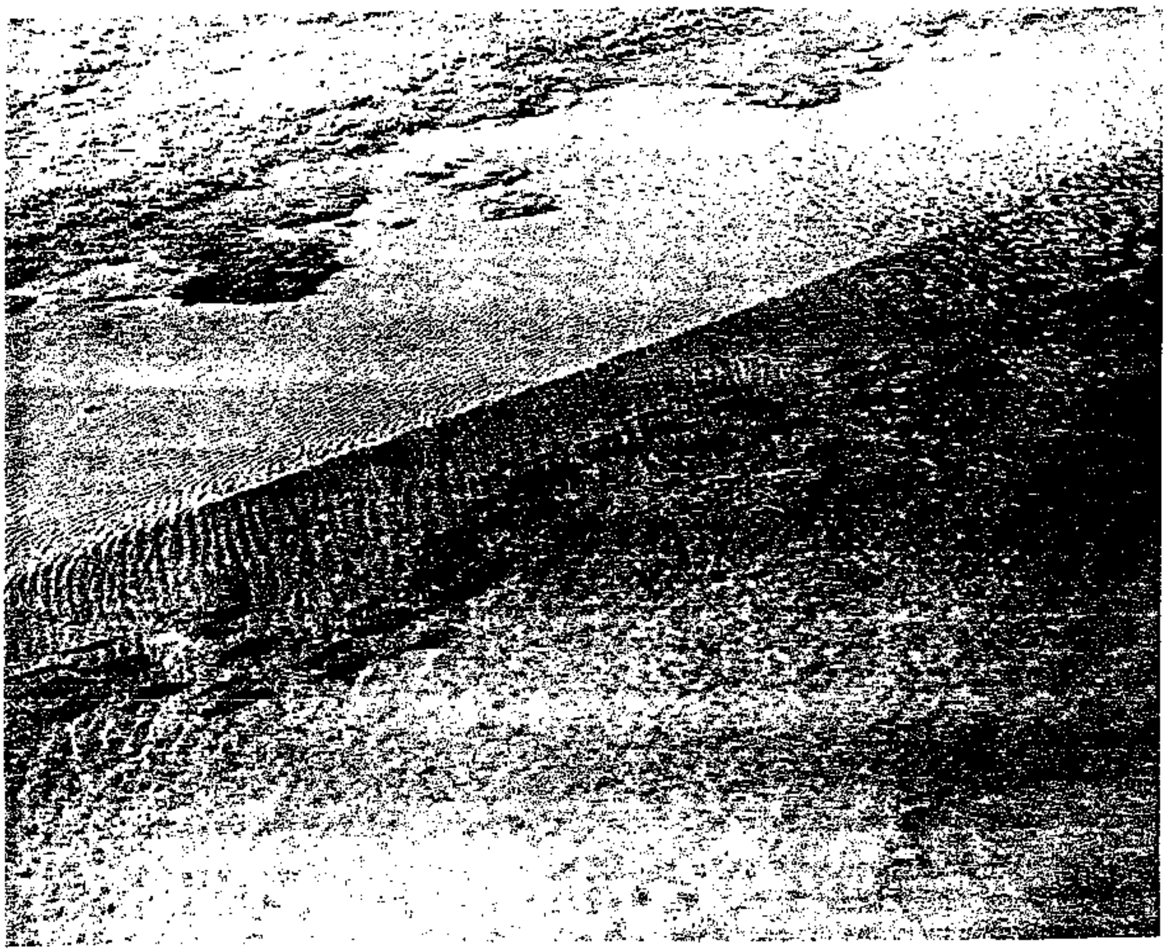

Fig. 4 Migrating Red Salmon, Egegik River, 1956

Only one tower below the weir was equipped with flood lights. A rheostat allowed the light intensity to be controlled. Although no upstream migrating fish were observed to be passing this tower after dark, it was found that many adult fish were returning to the lagoon during the early dark hours. In general, a light intensity bright enough to clearly disclose the presence of fish startled or frightened the fish. Less light intensity seemed to be less frightening to the fish. Vibrations from the gasoline driven 110 volt A.C. generator seemed to have no effect on migrating fish. The generator was operated during daylight migration to determine whether its vibrations would disturb fish movement.

It was observed that many fish were either reluctant to pass through the weir counting gates, or could not efficiently locate the gate openings. The fact that fish approached the weir daily and returned to the lagoon area in the evening and the presence of large numbers of fish milling below the weir suggests that the weir was a partial block to migration.

Determine the Relative Completeness of Tower Counts and the Factors which Equate Them to the Weir Counts

The towers below the weir were found to be improperly located to enumerate the escapement because of the large numbers of fish moving downstream. Towers located above the weir provided an estimate of the escapement that agreed favorably with the estimate furnished by the operation of the weir. For the periods July 12-30 inclusive, during which comparable tower and weir counts were attempted, weir operators estimated the Egegik escapement as 1,064,000 red salmon. An estimate based on the upstream tower counts indicated the escapement for this period to be 985,000 fish or 7.4 per cent lower than the weir estimates. (Table 1 and Fig. 5)

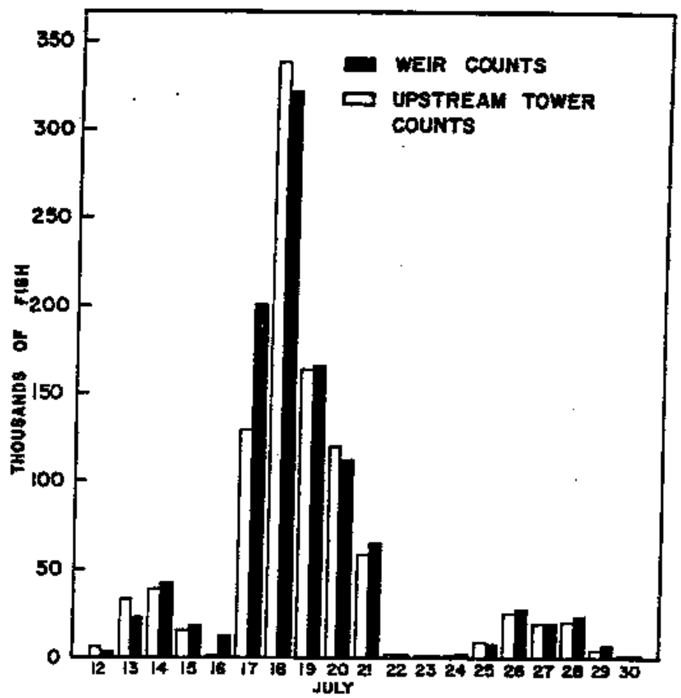

Fig. 5 Red Salmon Enumeration, Egegik River 1956

Probably the weir estimates for certain days were high. It was noted that some counting occurred with a single gate opened and the counting conducted for the first 20 minutes per hour. This would tend to make the resulting estimates high, since the counts were occurring on fish that had accumulated during a period when the weir was closed and tended to diminish after the weir was opened. With four gates open continuously and counts made early in each hour at two and late in each hour at the other two, such bias would not exist.

Much of the 7.4 per cent difference was due to the counts on July 16 and 17 when the tower estimates were 15,000 and 73,000 lower than the weir estimates. On these days, fish passed through the left side of the weir for the first time during the season, and it was not until noon of the second day that a tower could be erected on the left

TABLE I - COMPARISON OF WEIR AND TOWER ESTIMATES

RED SALMON ESCAPEMENT, EGEGIK RIVER, 1956

July	Weir Estimate	Tower Estimate	Actual Diff. In Estimates	% Deviation Tower from Weir
12	3,280	6,801	3,521	107.3
13	24,361	33,512	9,151	37.6
14 1/	41,415	37,243	4,172	- 19.1
15	19,455	17,554	1,901	- 9.8
16 2/	15,730	626	15,104	- 96.0
17 3/	200,342	126,892	73,450	- 36.7
18	322,536	336,535	13,999	4.3
19	167,859	165,317	2,542	- 1.5
20 4/	112,911	119,544	6,633	5.9
21	64,615	57,510	7,105	- 11.0
22	2,323	2,262	61	- 2.6
23	510	461	49	- 9.6
24	1,707	1,454	253	- 14.8
25	8,802	8,916	114	1.3
26	27,304	25,386	1,918	- 7.0
27	19,392	19,080	312	- 1.6
28	23,434	20,268	3,166	- 13.5
29	6,407	4,439	1,968	- 30.7
30	1,494	1,108	386	- 25.8
TOTAL	1,063,877	984,908	78,969	- 7.4

1/ Holes discovered in weir. Repaired at 8:00 a.m.

2/ Fish counted through left side of weir for first time today. No tower covering left bank yet.

3/ Most of morning spent erecting tower on left bank. Activity caused fish to veer out and escape count.

4/ Holes discovered in weir. Repaired at 11:00 a.m.

bank to obtain counts of fish passing up the left bank. Insufficient personnel prevented earlier erection of this tower. If we omit these two days, then the total estimate from tower counts was 1.6 per cent lower than the weir estimates.

The discovery of holes in the weir on July 14 and 20 indicates that weir estimates for July 12, 13 and 20 were probably low and that the differences in the estimates for these days would have been minimized, had the holes not occurred.

Complete analysis of the data has not yet been made, but it may be concluded now from these studies in the Egegik River that tower counts do not need to be multiplied by a factor to equate them to weir counts. If the towers are properly located and adequate provisions made for good visibility all of the fish can be seen. Whether there is enough downstream movement at the upriver sites to complicate the counting can be determined only by removing the weir.

Determine the Minimum Counting Effort Required to Provide the Desired Degree of Accuracy in Counting the Daily Number of Salmon Passing the Counting Sites

Little data are on hand with which to determine from a biological standpoint the degree of accuracy needed to enumerate the Egegik escapements. The past escapement figures indicate a range of about 200,000 to 2,000,000 in the annual red salmon escapement into the river. With such large fluctuations in the escapement evident, a lesser degree of accuracy is probably acceptable than if the escapement fluctuation were of smaller magnitude.

Tower estimates during 1956 were based principally on 30 minutes of counting per hour; i.e., 15 minutes of counting with 15 minutes of rest between counting periods. The resulting estimate was within 1.2 per cent of the estimate furnished by the weir. July 16 and 17 comparisons are disregarded because tower coverage was incomplete. Assuming the same accuracy for a small run of 200,000 fish, the tower estimate would be 197,600. Likewise, an estimate for a large run of 2,000,000 would be 1,976,000, which intuitively, appears to be a close enough estimate.

It is desirable to examine the estimates based on shorter periods of counting in order to determine the minimum amount of counting that will produce a reliable estimate of the escapement. During part of the season, five-minute subtotals were recorded during each 15-minute counting period. For the period July 14-27,1956, (which contained the peak of the run) data were obtained to estimate the number of fish passing the towers from counting periods of 5, 10, 15 and 30 minutes per hour. A statistical exploration of these data indicates that a greater variation will occur in the estimated totals based on one 5 minute-per-hour count than in estimated totals based on longer counting periods (Table 2). On this basis ninety-five per cent of the time the basic sampling scheme of two 15 minute-per-hour counts will permit an estimate within 3.9 per cent of the actual total escapement. Using a sampling scheme of one 5 minute-per-hour count, the error will be less than 7.6 per cent. Estimates within the latter limits of accuracy appear to be entirely acceptable in light of present knowledge.

TABLE 2

Comparable Accuracy of Estimates Based on Various Counting Periods

Counting Periods per hour	Standard error of Est. Total 1/ No. Migrants	% Est. Total	95% limits of error (1.96Xstandard error)
Two 15 minute	18,259	1.99	3.90
One 15 minute	31,625	3.45	6.76
One 10 minute	28,412	3.10	6.08
One 5 minute	35,355	3.86	7.56

1/ Estimated total for July 14-27 = 915,721

Other Data Obtained in 1956

A thermograph was in operation from June 19 to August 7 inclusive, and the recording charts are in Bristol Bay research files for future analysis. Daily air temperatures were also recorded.

Weather observations were recorded daily.

Miscellaneous observations were recorded in the field diaries maintained by each of the personnel.

Recommendations for 1957 Egegik Enumeration

It is believed that a crew of three men operating for six weeks from about June 20 to August 5 can adequately enumerate the Egegik spawning escapement by tower counting if they are concerned only with the counts and the resulting estimates. However, further study is needed on the extent and manner of night migration. Likewise, further study is needed on how to improve visibility from the towers on windy and overcast days. For this reason, at least one or two more men will be needed depending upon the extent that related studies are carried out. The following recommendations are offered:

A. Select tower sites for counting along the left and right banks and a third tower for spot checks. Tower sites should be selected to fulfill the following requirements: (1) Be where fish migrate in a single path and all can be distinctly observed; (2) be in the lee of sheltering river banks that will protect from wind and current surface disturbances; (3) be where river bed will silhouette individual fish; and (4) be where low morning and evening sun causes minimum glare for the observer.

B. Conduct further studies to improve visibility and to determine whether night counting is necessary.

C. Improve the operational techniques and personal comfort of the observers.

1. Construct prefabricated shelters for all towers.
2. Obtain intervalometers that will audibly signal the beginning and ending of each counting period.
3. Use prepared forms on waterproof paper to simplify keeping and summarizing basic data.
4. Construct log triangle to smooth the water. These should be about 30' to the side and rigidly bolted together to float on the surface.
5. Mark boat channels with buoys.

Submitted by:

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January 2, 1957

Approved by:

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Bureau of Commercial Fisheries, Juneau, Alaska

Western Alaska Salmon Investigations

Field Report on the Evaluation of Towers for Counting Migrating Red Salmon in Bristol Bay, 1957

INTRODUCTION

Due to the expense, time involved in construction and maintainence of weirs, and because of probable interference with salmon migration, a less expensive and more convenient method of enumerating Bristol Bay red salmon escapement was needed.

In recent years counting towers have been developed and used successfully by the Fisheries Research Institute. These towers are considerably less expensive than weirs and are easily erected and maintained.

In 1956, to test directly the reliability of towers, the Fish and Wildlife Service made a comparison between tower and weir estimates on the Egegik River. The resulting estimates compared favorably. Based on this knowledge, 1957 escapement estimates on Naknek, Egegik, Alagnak, and Ugashik Rivers were made by counting from towers. On the wider and more turbulent Naknek River, counts from towers and the weir were obtained and compared to check the feasibility of future removal of the Naknek weir.

DESCRIPTION OF STUDY AREAS

Naknek River

The Naknek River (Fig. 1) is about 35 miles in length from Naknek Lake to its mouth in Kvichak Bay. The river banks are mostly free from trees and other wind sheltering growth. Two towers, one on each bank, were used for counting on the Naknek River. A third tower located about 20 yards out in the stream off the right bank was utilized part of the season.

Ugashik River

The Ugashik River (Fig. 2) is about 35 miles in length from its source at the outlet of Lower Ugashik Lake to its mouth in Bristol Bay. The river banks are mostly free from trees and other wind sheltering growth. Three towers were used on the Ugashik River. They were located, one on each bank and one in midstream.

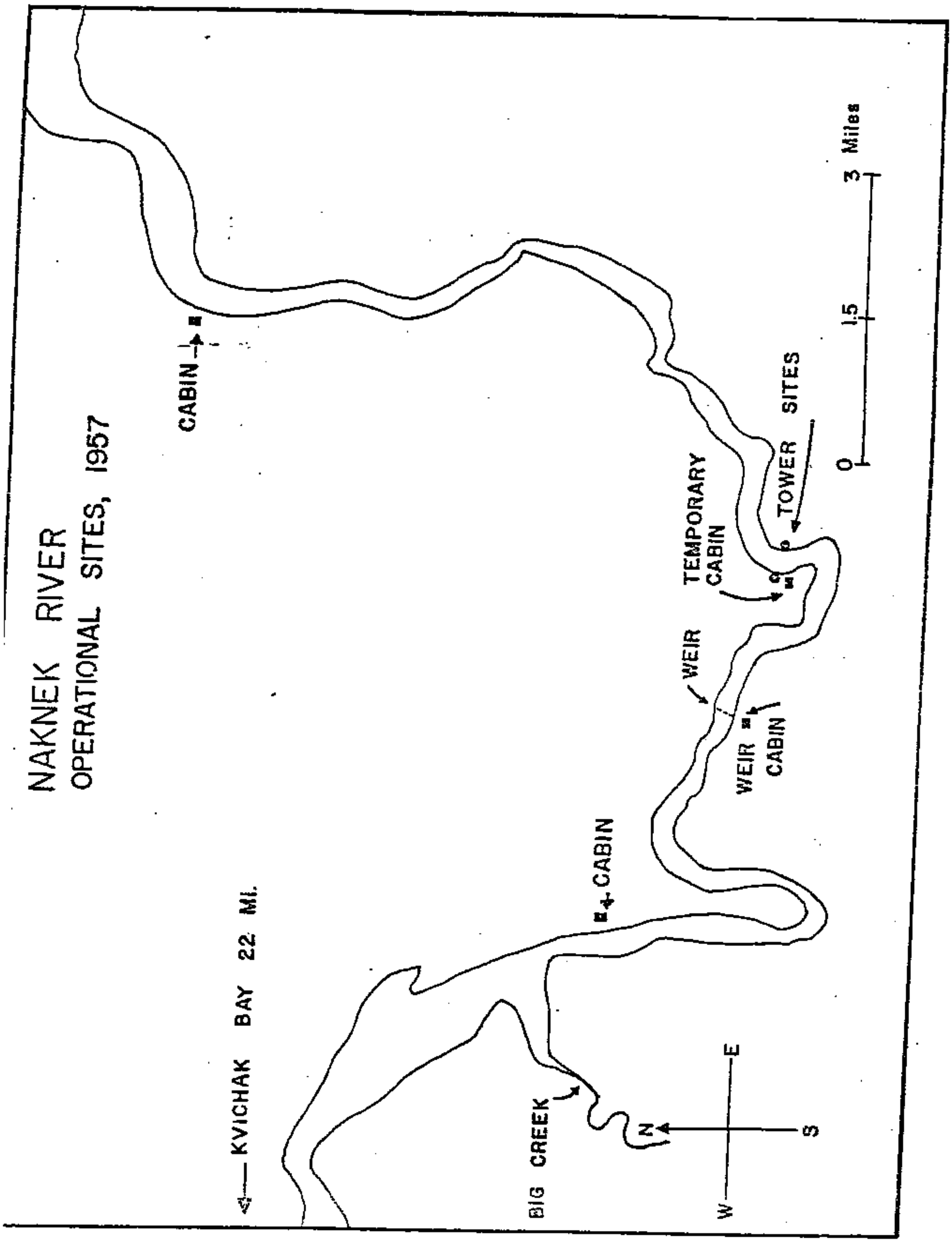

Figure I. Map of Naknek River Area

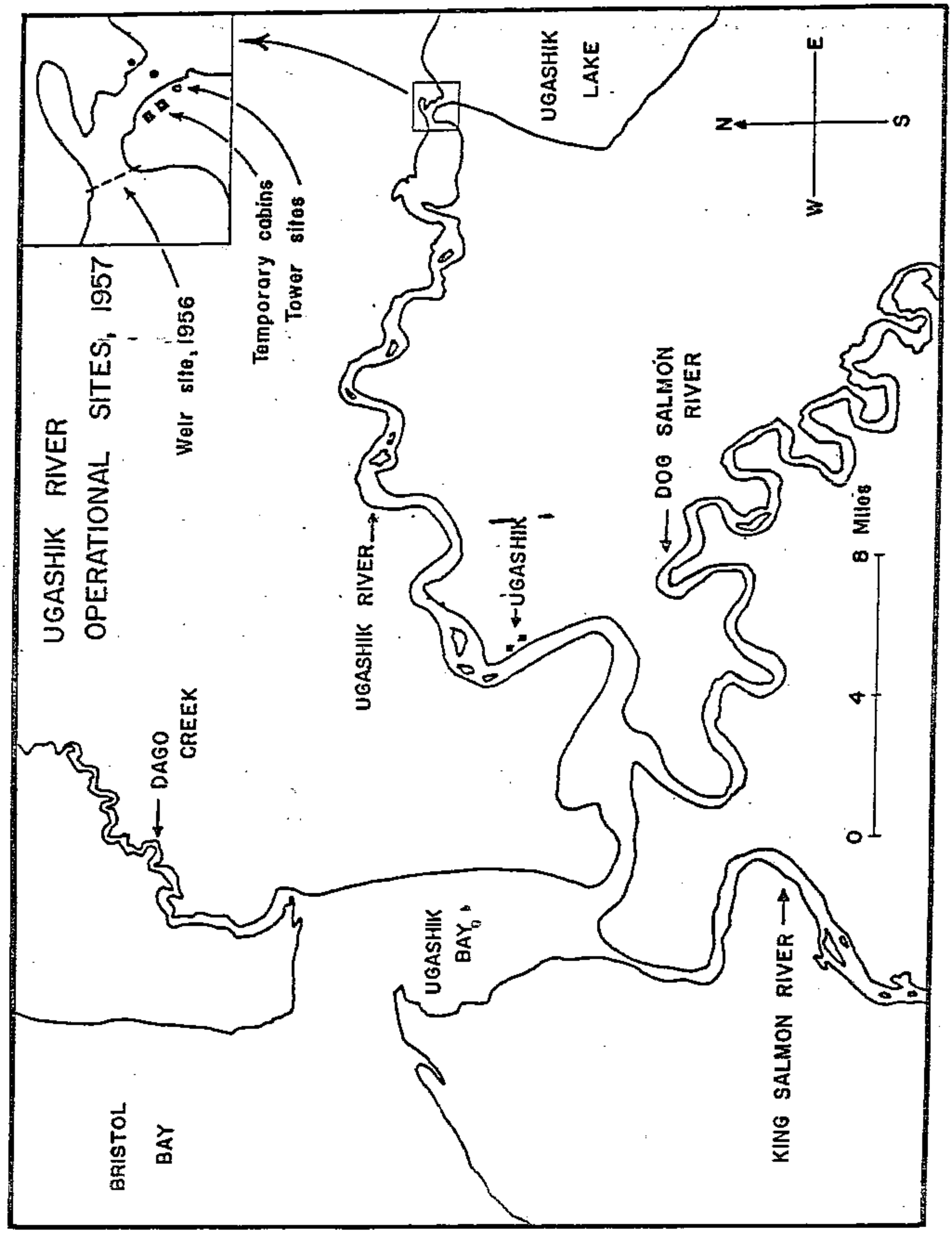

Fig. 2. Map of Ugashik River Area

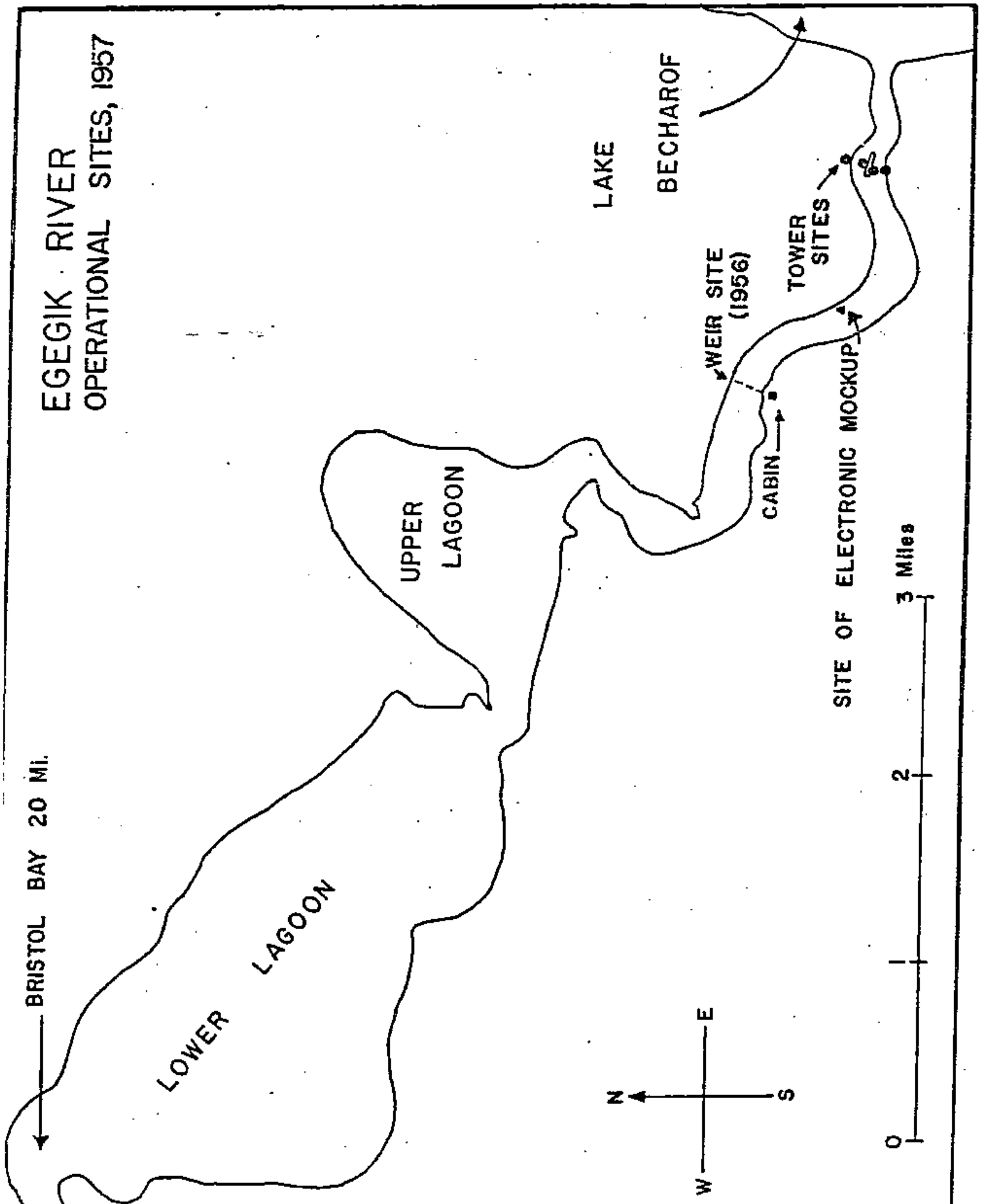

Figure 3. Map of Egegik River Area

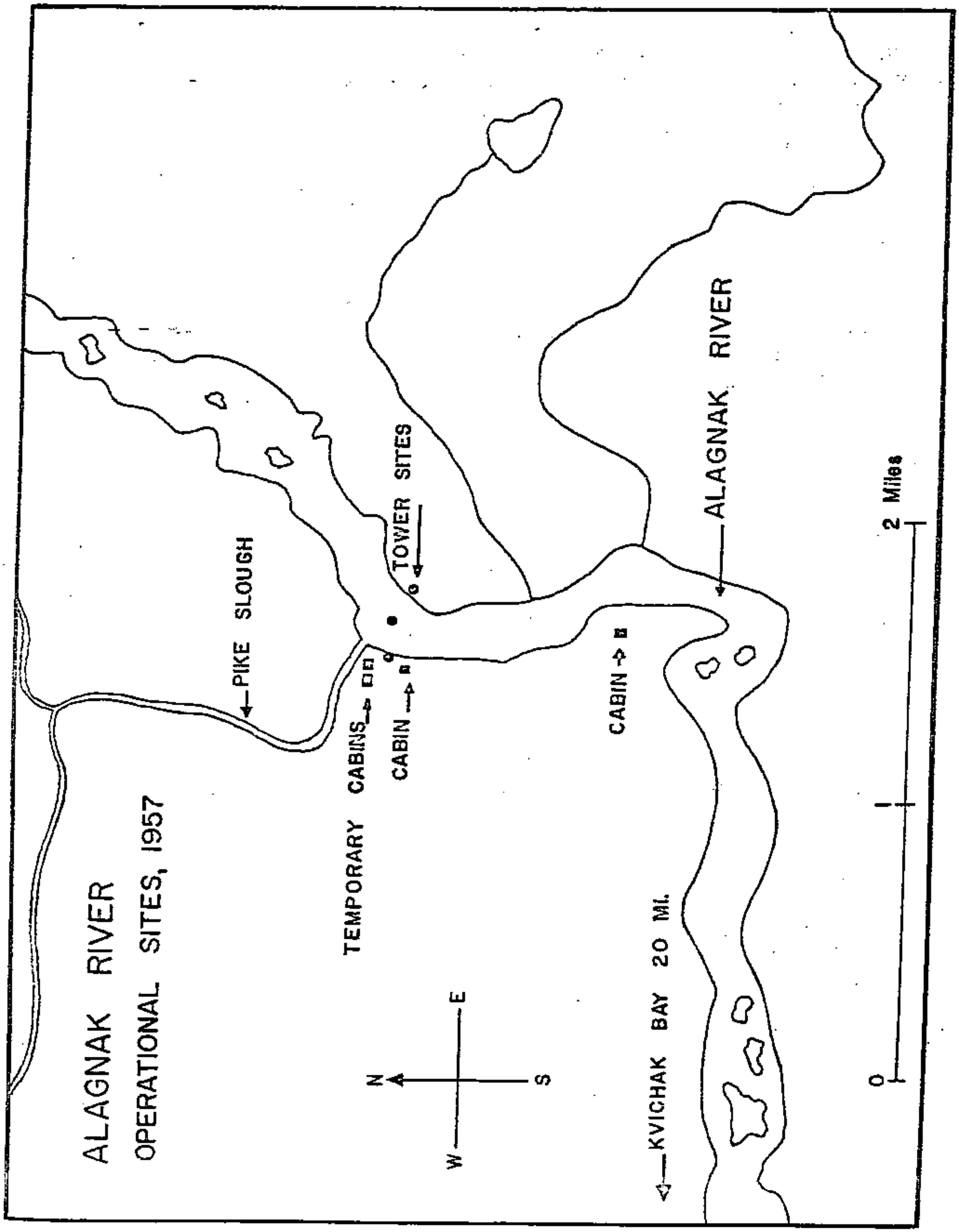

Figure 4. Map of Alagnak River Area

Egegik River

The Egegik River (Fig. 3) is approximately 25 miles in length from its source at the outlet of Becharof Lake to its mouth at Bristol Bay. Tidal influence is noticeable along the river below the relatively swift rapids of the uppermost mile. The river banks are free from trees and other wind sheltering growth. Four towers were used on the Egegik River. These were located one on each bank of the river, and one on each side of the intervening island.

Alagnak (Branch) River

The Alagnak River (Fig. 4) is about 50 miles in length from its source at Kukaklek Lake to its mouth in Kvichak Bay. The river banks are mostly free from large trees along the lower 15 miles. Three towers were used on the Alagnak River. They were located, one on each bank and one in midstream.

OBJECTIVES

General Statement

In the case of some objectives, work was carried out at one or more operational sites. The area (s) at which each particular objective was investigated is cited in parenthesis behind the respective objective.

Specific Objectives

1. Select adequate tower sites and reliably estimate the daily red salmon escapement. (Naknek, Ugashik, Egegik, Alagnak).

2. Operate the tower in conjunction with the weir and compare the estimates of daytime, nighttime, and seasonal migration furnished by each. (Naknek).

3. Conduct fish behavioral studies related to lighted background paneling and visibility improvement equipment. Study, as an aid to future development of electronic counting methods, the minimum spacing of poles and grids through which fish will pass without diverting from their normal migration path. (Egegik).

4. Develop equipment, methods, and techniques towards obtaining a reliable estimate of red salmon escapements with a minimum of effort and expense. (Naknek, Ugashik, Egegik, Alagnak).

5. Integrate selected management personnel with research tower counting crews to provide them with experience in tower counting methods and techniques, (Naknek, Ugashik, Egegik, Alagnak).

OPERATIONS

General Statement of Operations

Since the work conducted at the four different areas varied considerably, operations at each area are given separately.

Intervalometers were used at all tower counting sites to mechanically indicate counting periods. This was necessary because of the complex multi-period counts needed to establish a minimum counting period, which would still allow accurate estimations to be made.

Counts conducted from the Ugashik, Egegik, and Alagnak tower sites were made for ten minutes per hour. Periods of 15 minutes per hour were counted on the Naknek towers. Subtotals were recorded for each five minute period at all sites.

At all sites counts were recorded on Veeder-Root hand tallies and entered at intervals in field books carried by each man. Data were transcribed each day and appropriately weighted to furnish estimates of the daily migration.

In most cases counts were conducted from 0400 until 2100. Any counts missed during these hours were interpolated by using the average of the hourly estimates immediately preceding and following the missing count.

Estimates between 2100 and 0400 present a different problem due to the following possible sources of error: (1) Some fish may escape unnoticed when counting at night without artificial light. (2) Artificial light might be attractive or conversely, frighten fish so the normal night migration rate would be distorted. (3) Twenty-four hour counts, upon which a correction factor might be based, are available for only 1/3 of the days on which counts were made. Four of these 21 days were counted during the peak of the run. If 24 hour counts were available for all days on which counts were made, a more accurate correction factor could be ascertained.

Based on the available data a correction factor of 2.4 percent of the daily total, on the Alagnak, was interpolated for each missing hour between 2100 and 0400. On the Ugashik, a correction factor of 0.4 percent of the daily total was interpolated for the missing hours between 2100 and 0400. On the Egegik River where no 24 hour counts were made, the Ugashik factor of 0.4 percent was used because of the similarity of the two streams and operation sites.

Naknek Area Operations

A crew of three research seasonal employees (Table 1) arrived at the Naknek tower on June 19 under the crew leadership of Jack Mell. The management fishery aid arrived June 22. Following the transfer of Mell to King Salmon on July 3, Jack Woody became crew leader. This study was terminated on August 6, and the crew returned to King Salmon.

Table 1.—Naknek tower personnel, 1957

Name	Arrival at operation site	Departure from site
Andervont, David	June 19	August 6
Hitchcock, Daniel	June 22	August 6
Mell, Jack	June 19	July 3
Metcalf, Frank	July 9	August 6
Woody, Jack	June 19	August 6

Two towers, one on the right bank and one on the left bank, were used for red salmon enumeration. Weir counts were made concurrently with the tower counts for comparative purposes. Illustrations (Fig. 5 and Fig. 6) show a tower and the weir used on the Naknek River.

Fig. 5 A counting tower used on the Alagnak River

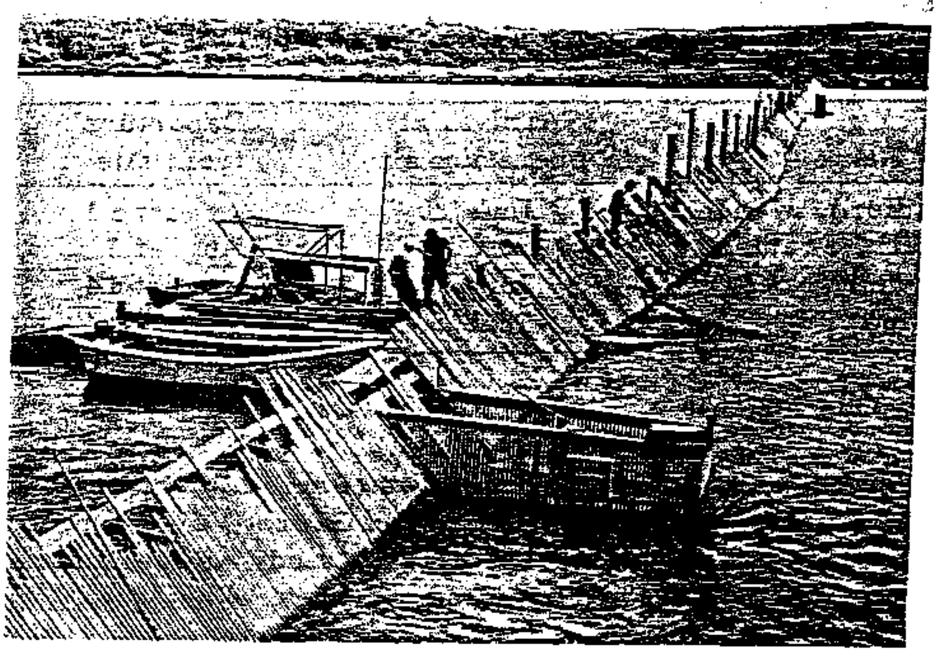

Fig. 6 Weir used on Naknek River (1956)

Counting was conducted from each tower for fifteen minutes per hour from 0400 until dark. (Each shift was of 4 to 6 hour duration depending upon the availability of personnel.) Some night counting was carried out with unsatisfactory results caused by the inability to get fish to migrate normally through a lighted area.

When counts were made at weir gates, the gates were open for a period of one hour. Counting was conducted from the weir gates for 20 minutes per hour. The counting periods varied with the abundance of fish but were usually made from 0600 until dark. Some counts were also made after dark to obtain information on nighttime migration.

Ugashik Area Operations

Two seasonal employees (Table 2) arrived at the Ugashik tower site on June 20 and Noel Tugwell, the crew leader, arrived June 25. Francis Schutz, a management fishery aid assisted during the peak of migration.

Counting was conducted from each of the three towers for ten minutes per hour. Counts were made from 0400 to dark with night counting conducted during the heaviest part of the run.

Table 2.—Ugashik tower personnel, 1957

Name	Arrival at operation site	Departure from site
Bradford, Wendell	June 20	August 14
Schutz, Francis	July 5	August 7
Tugwell, Noel	June 25	August 14
Yovino, Joe	June 20	August 14

Egegik Area Operations

A crew of three seasonal employees (Table 3) arrived at the Egegik site on June 19 under the crew leadership of Garret Van Wart. Additional men arrived as the season progressed. This study was terminated on August 12, and the crew returned to King Salmon.

Table 3.—Egegik tower personnel, 1957

Name	Arrival at operation site	Departure from site
Carlson, Charles	June 19	July 26
MacVean, Duncan	June 19	July 26
Metcalf, Frank	June 22	July 8
Strickland, Charles	June 27	August 12
Van Wart, Garret	June 19	August 12

In addition to the regular tower counting personnel, Jerry O'Gorman, Bert Ewing, Herb Shiro, and James Milne (cook) assisted at various times in connection with their duties on the smolt and sampling methods studies.

Counting was conducted from each of the four towers for 10 minutes per hour. Counting was alternated on the middle towers and only counted every other hour. A counter alternated counting and resting each 10 minutes during his four hour shift. Counts were made from 0400 until dark, with some attempts made to count at night with artificial light.

Alagnak (Branch) Area Operations

A crew of three seasonal employees (Table 4) arrived at Alagnak on June 24 under the crew leadership of John Black. Counting was discontinued on July 29 and the crew secured camp and returned to King Salmon on August 4.

Table 4.—Alagnak tower personnel, 1957

Name	Arrival at operation site	Departure from site
Black, John	June 24	August 4
Borgeson, David	June 24	August 4
Erickson, Charles	June 24	August 4

Counting was conducted from each of the towers for ten minutes per hour in order to obtain estimates of the hourly, daily, and seasonal migration. Counts were made from 0400 until dark.

A deflector was successfully used to sheer fish closer to the bank and across the background panels. During the latter part of the season, the water level had fallen almost two feet and the migrating red salmon passed the right bank tower much farther out than previously. A 3/8 inch manila line was rigged with white 2" by 8" plywood panels and anchored on the bottom to act as a lead. The panels bobbed and waved in the current and led fish across the background panels. This device appears to have great promise in directing fish towards better areas of visibility.

RESULTS

Selection of Adequate Tower Sites and Estimate of Escapement

Based upon a reconnaissance by air or foot, tower sites were selected. The sites chosen were based on the probable salmon migration path, depth of water, width of stream, color of stream bottom, protection from wind action, and glare from the sun.

The Ugashik River escapement for the period of July 5 to August 9 inclusive, was estimated to be approximately 214,800 red salmon. The graph (Fig. 7) presents the daily estimated escapement.

The Egegik River escapement for the period of June 30 to July 30 inclusive, was estimated to be approximately 391,200 red salmon. The daily estimated escapement is graphically presented (Fig. 8).

The Alagnak River escapement for the period of June 29 to July 29 inclusive, was estimated to be approximately 126,600 red salmon. Daily estimated escapement is graphically shown (Fig. 9).

Comparison of Towers with Weir

During the period from June 29 through July 31 comparable tower and weir counts were obtained. (Figure 10 graphically presents daily escapement past the towers and the weir.)

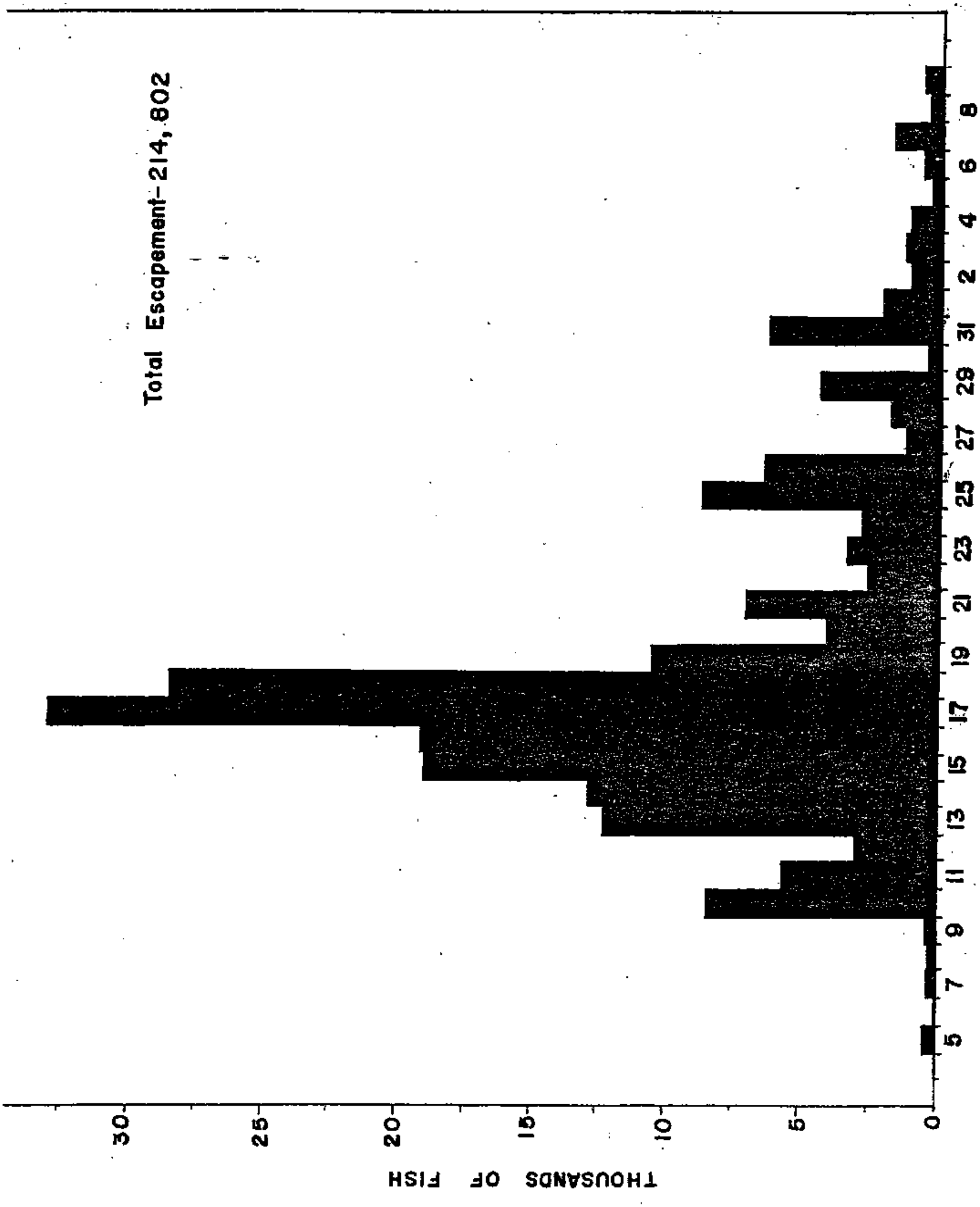

Figure 7. Daily Escapement of Red Salmon, Ugashik River, 1957

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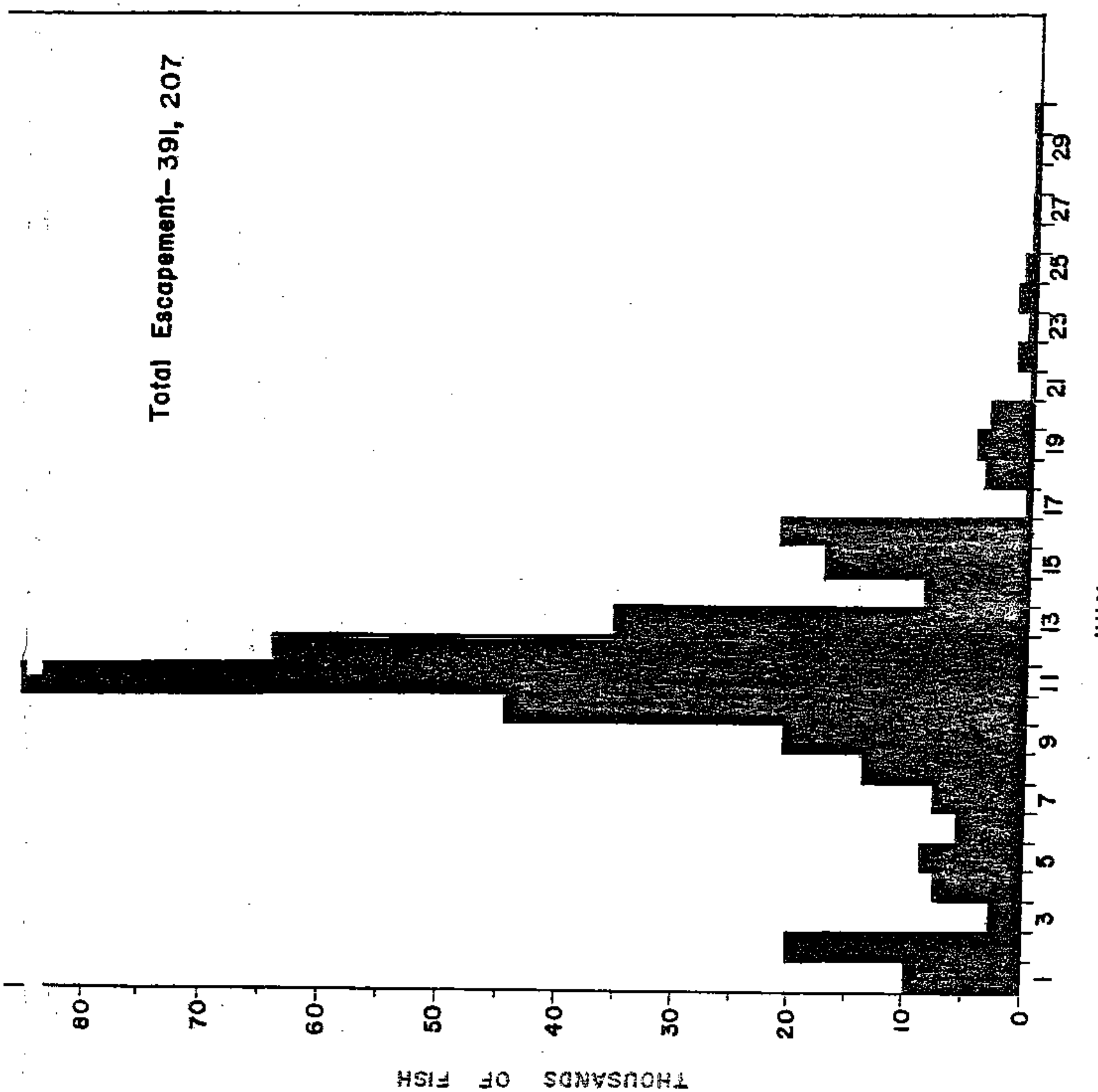

Figure 8. Daily Escapement of Red Salmon, Egegik River, 1957

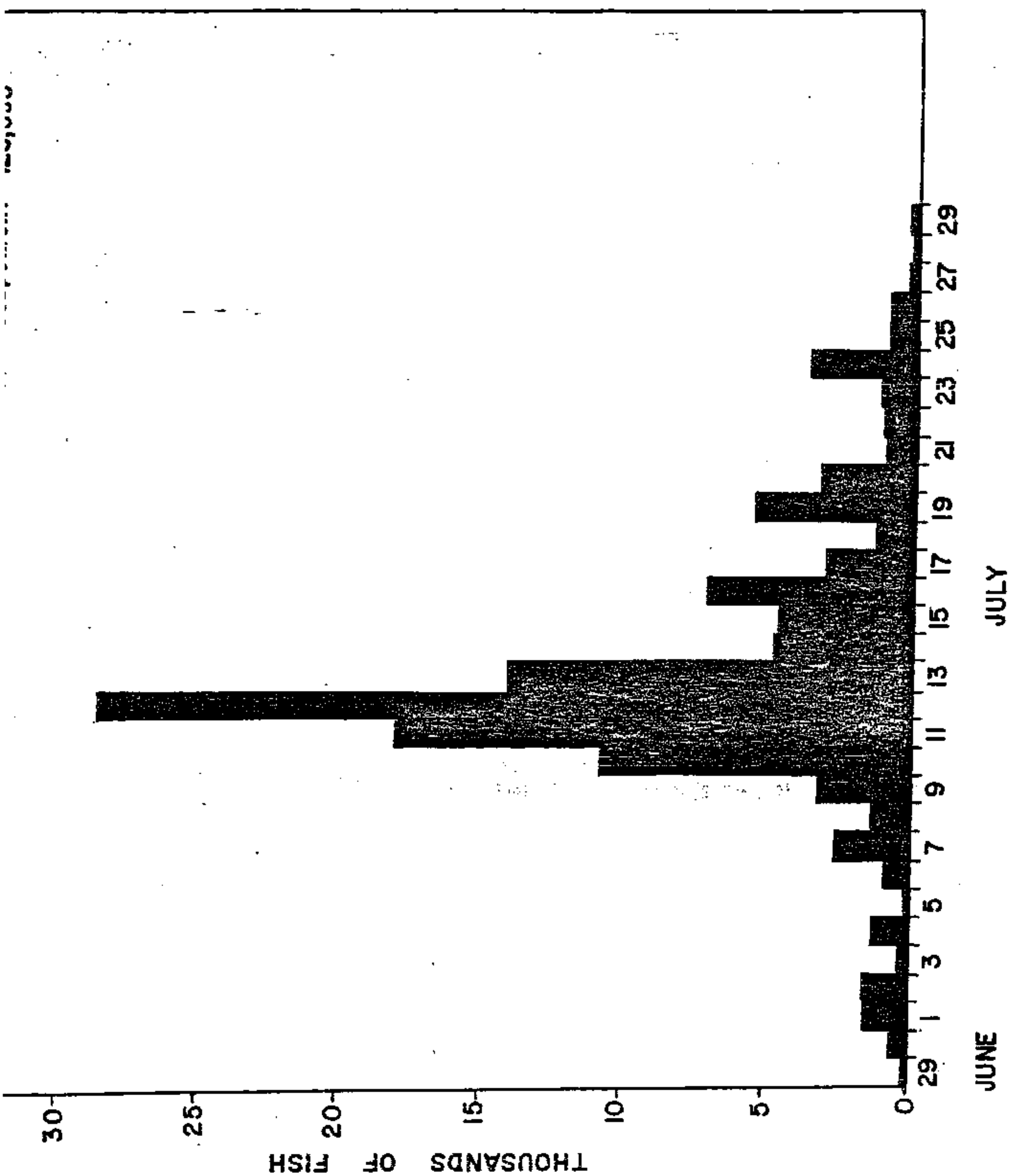

Figure 9. Daily Escapement of Red Salmon, Alagnak River, 1957

In this time weir operators estimated an escapement of approximately 631,000 red salmon while tower operators estimated an escapement of approximately 712,000 fish, or 12.8 percent more than the weir estimate. Examination of the graph (Fig. 10) reveals that most of the error between tower and weir counts occurred on July 8 and 9 during the peak of the run when the tower estimates were 51,000 and 25,000 higher than weir estimates. If we omit these two days, then the total estimate from tower counts was only 0.9 percent higher than the weir estimate.

The fact that tower estimates (Table 5) were higher this year suggests the following: (1) The weir may have developed leaks unnoticed by weir operators, thus allowing some fish to escape uncounted through the weir; (2) Tower counters overestimated escapement on July 8 and 9 during the peak of the run; (3) Weir counters underestimated escapement through the 16 inch wide gates on July 8 and 9 during the peak.

Artificial Lighting for Night Counts

Various preliminary tests (Table 6) on night lighting in relation to fish behavior were conducted at the Naknek weir on July 8, 9, 10, and 14.

It should be pointed out that the information in Table 6 is not offered as conclusive. These results merely afford indications for guidance in future investigations.

Although inconclusive, the results seem to indicate that red lighting is less acceptable to the fish since only 18 salmon were counted through the weir in two 1/2 hour periods where red lighting devices were used. On the same night a gate was operated without lights, and 77 fish were counted through in 5 minutes. On July 9, 10, and 14, during simultaneous nocturnal counts, approximately 6,496 red salmon were counted through weir gates 6 and 7. From this total 95 percent were counted through gate 6 which was provided with white light. The remaining 5 percent passed through gate 7 which which was not provided with artificial light. Diurnal counts through these gates on July 9, 10, and 14 totaled 69,227 fish and from this total, 56 percent passed through gate 7 and the remaining 44 percent passed through gate 6 indicating little preference for either gate under similar light conditions. This seems to indicate that white light may actually attract some fish through the counting gates.

Background Panels, Rippledamper, and Electronic Counting Aids

On the Naknek River 4' by 8' bottom background paneling for silhouetting fish was tried at the weir with apparent success. A length of six-thread manila line was laced through one edge of a roll of 4' wide 1" mesh chicken wire and the rope laid towards midstream to a sheave attached to an anchor. The roll of wire was then unrolled from the beach

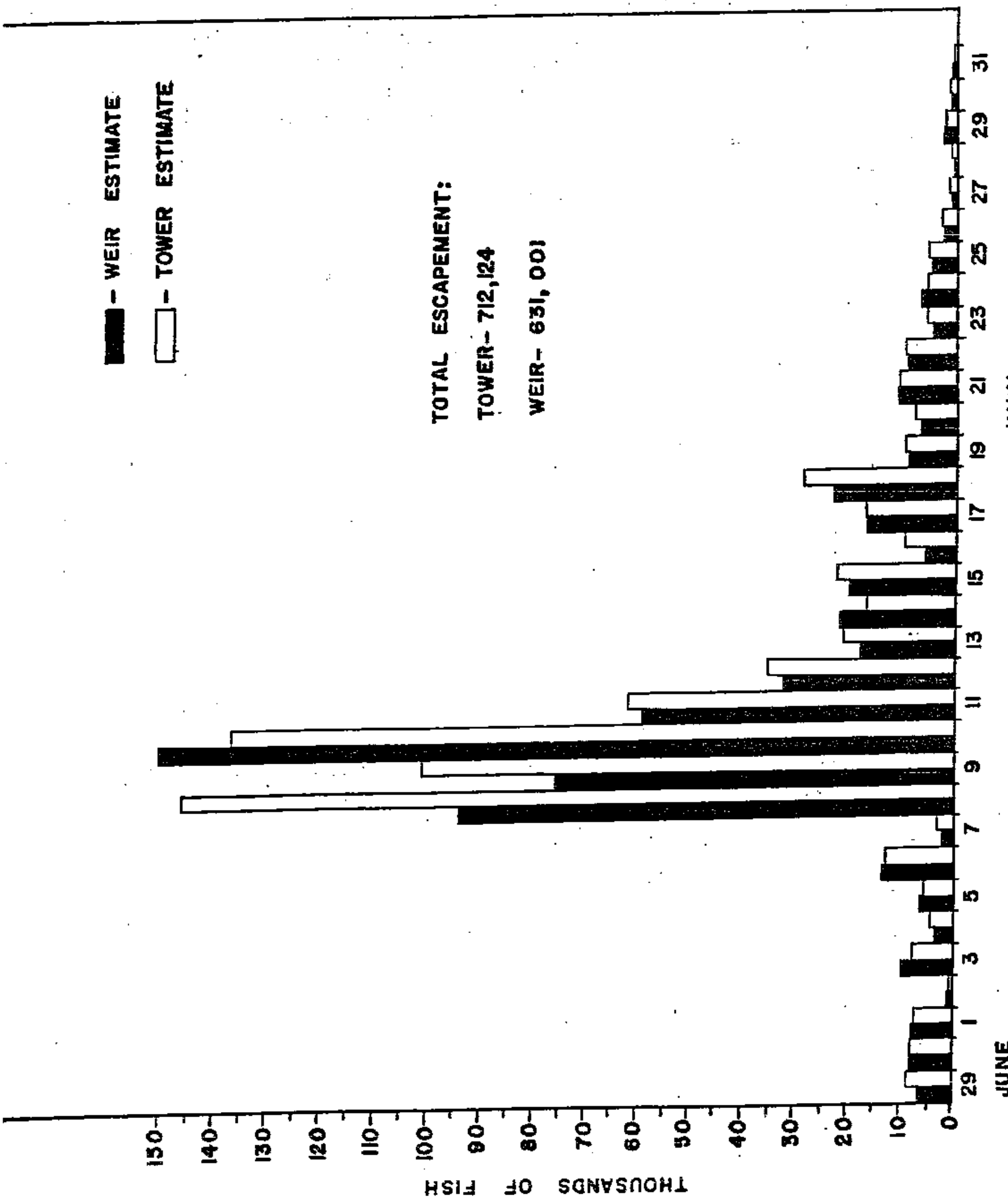

Figure 10. Daily Escapement of Red Salmon, Naknek River, 1957

Table 5.—Comparison of tower and weir estimates of red salmon escapement, Naknek River, 1957

Date	Weir	Tower	Difference in estimates	Percent deviation tower from weir
June 29 1/	6,375	8,040	1,665	26.1
30	7,401	7,560	159	2.1
July 1	7,437	7,420	— 17	— .2
2	1,380	728	— 652	—47.2
3	9,831	7,604	— 2,227	—22.6
4	3,704	4,336	632	17.1
5	6,350	5,284	— 1,066	—16.8
6	13,777	12,896	— 881	— 6.4
7 1/	2,662	3,188	526	19.8
8	93,592	145,204	51,612	55.1
9	75,436	100,408	24,972	33.1
10	149,787	136,072	—13,715	— 9.2
11	58,415	61,256	2,841	4.9
12	32,052	35,104	3,052	9.5
13 1/	17,072	20,708	3,636	21.3
14	21,079	16,600	— 4,479	—21.2
15	19,659	22,032	2,373	12.1
16	5,943	9,324	3,381	56.9
17	16,563	16,788	225	1.4
18	22,411	28,268	5,857	26.1
19	8,916	9,160	244	2.7
20	6,203	7,544	1,341	21.6
21 1/	10,862	10,764	— 98	— 0.9
22 1/	8,693	9,352	659	7.6
23	4,242	5,208	966	22.8
24	6,228	5,536	— 692	—11.1
25	4,887	5,072	185	3.8
26	2,536	2,712	176	6.9
27	1,633	1,880	247	15.1
28	856	1,152	296	34.6
29 1/	2,647	2,304	— 343	—13.0
30	1,336	1,620	284	21.2
31	1,036	1,000	— 36	— 3.5
Totals	631,001	712,124	81,123	12.8

1/ Leak found in weir.

Table 6.—Effect of lighting devices on red salmon migration, Naknek Weir, 1957

Date	Time	Light source	Time in minutes	Number of fish	Number fish/hour	Gate number	Remarks
July 8	2230 2300	25 watt red light	30	16	32	7	
8	2300 2305	no light	5	77	924	7	
8	2315 2321	50 watt white light	6	58	580	7	Light appeared to blind fish
8	2330 2400	red lights	30	2	4	1	Underwater panel used
9	2300 0100	25 watt white light	120	129	65	6	white gate frame upstream side; white cloth cover 1/
9	2300 0100	no light	120	9	5	7	white gate frame upstream side 1/
10	2330 2430	25 watt white flood light	60	5196	5196	6	white gate frame upstream side; seven gates open 1/
10	2330 2430	no light	60	285	285	7	white gate frame upstream side; seven gates open 1/
14	2300 2400	25 watt white light	60	909	909	6	white gate frame upstream side; white cloth cover 1/
14	2300 2400	no light	60	36	36	7	white gate frame upstream side 1/

1/ Thousands of fish below weir.

and pulled across the bottom to the anchor via the line. This placed the wire mesh on the stream bottom and allowed it to be pulled out from the bank to any desired length to reach the migration path of the fish. It is believed that this method will simplify placement and control of background panels to better silhouette migrating fish.

On the Ugashik River 4' by 8' panels of wire cloth were firmly anchored to the stream bottom. These panels were painted light green. The following marine paint mixture was used: 4 gallons of Co-ca-seal, white, 1/4 pint of Masstone raw umber, and 1 pint of Masstone dark chrome green pigment. The newly painted panels seemed to frighten some fish. This was rectified by scattering gravel over the panels. With age, the panels seasoned and lost any odor offensive to the fish.

In addition, a triangular floating "rippledamper" (Fig. 11) was constructed of three 6" by 6" timbers upon which are attached vertical slats (weir pickets). This arrangement smoothed the water surface within and downstream from the triangle. However, unless the ropes from the "rippledamper" were kept well away from the migration path, they frightened some fish.

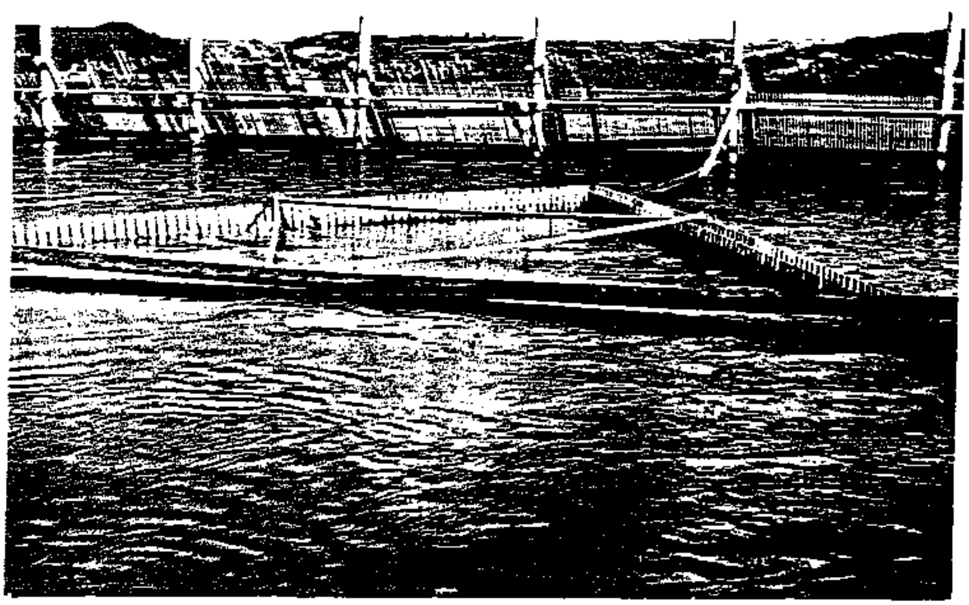

Fig. 11 "Rippledamper" used to smooth water surface for improving visibility

On the Egegik River studies on night lighting, background paneling, and visibility improvement were also carried out. On July 14, four background panels were placed on the left bank just below the bank tower. The panels were operated steadily for 15 minutes from 2330 to 2345. By means of a rheostat the light intensity was varied from dim to bright. In addition, five minute periods of darkness were tried with the panels being switched on suddenly. The only fish observed were two which were frightened away when the lights were first switched on. White light from a flashlight also frightened numerous fish which were resting only a few feet from shore.

In addition to the studies on visibility improvement, preliminary experiments were carried out as an aid to future development of electronic counting methods. Various arrays of stakes and a masonite grid (Fig. 12) were tested to determine minimum spacing that red salmon will tolerate without diverging from their normal migration path. Single rows of pickets spaced 12" and 18" apart passed fish successfully. A double row of pickets arranged 12 inches apart passed fish less successfully.

Panels of 1/4" masonite 12" wide were arranged across the migration path spaced 12" and 24" apart. The panels were secured in place by twin 2" by 6" stringers on the stream bottom, and twin 2" by 6" stringers immediately above the surface of the water. Individual panels could be lifted from the array to increase the width of the openings from 12" to 24".

Fish were reluctant to pass through the grid and veered out into deeper water and around the array. A 200 foot beach seine was then arranged as a lead on the outer end of the array with the same results. The bulky top

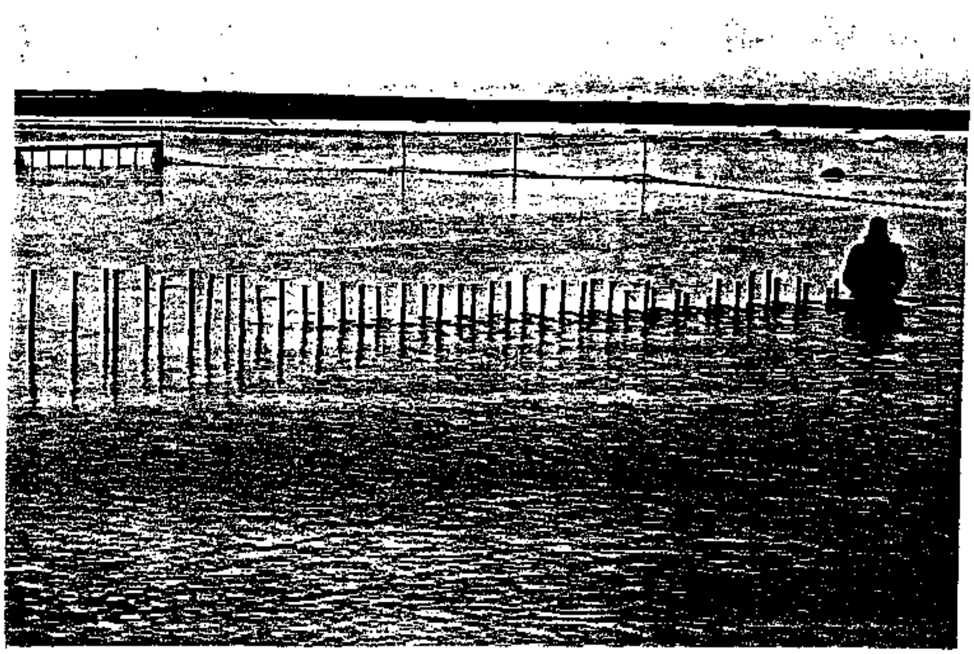

Fig. 12 Electronic mockup site with array of stakes in foreground and masonite grid at left in background

stringer was then removed and stove pipe wire substituted to secure the panels. Fish would not pass this array either. Alternate panels were subsequently removed leaving openings 24 inches in width. The use of the lead did not increase the efficiency of the array in passing fish.

The masonite grid is considered unsatisfactory in passing fish since only about five percent of the fish passed through the grid. Results are not conclusive however, and further testing using an array with more variable dimensions is needed.

Influence of Tidal Fluctuations on Migration Patterns

A water level recorder was installed in the Naknek River in order to study the relationship of the tidal influence to migration out of the lagoon area. Due to the distance from Bristol Bay to the recorder, tidal fluctuations are very slight. Although high tides are evident, daily fluctuations are not readily discernible because a 30 day recording arrangement was used which condensed daily variations on the chart. In the future the water level recorder will be placed at or nearer the mouth of the stream, and an 8 day recording arrangement will be used.

A water level recorder was also installed on the Egegik River but results were unsatisfactory for reasons similar to those given above.

Training of Management Crews

At each of the four operation sites at least one management fishery aid was integrated with the research tower counting crew and was familiarized with tower counting methods and techniques.

Concluding Remarks

Although the use of towers has been developed to the operational stage, additional research and development are required to increase their efficiency and simplicity of use. A thorough statistical analysis of the comparative accuracy of five, ten and fifteen minute-per-hour counting periods is in progress and will provide the basis for the length of hourly counting periods recommended for 1958.

Available evidence indicates that migration during twilight and dark hours is a minor and possibly negligible proportion of the total migration. Further study should be given to nocturnal migrations and if the data so warrant, night counting may be discontinued or reduced and the daily estimates increased by a factor representing the night migration or by interpolation between final counts of one day and initial counts of the next.

CONTENTS

ABSTRACT

The method of estimating red-salmon escapements used from 1955 to 1959 on the Kvichak River (Alaska) involved taking visually systematic sample counts as the fish passed observation towers beside the paths of migration. The counts followed a sampling design which fluctuated in extent of coverage with the intensity of the run. This report describes in detail the method of sampling and calculating the escapement estimates, summarizes the counts for each year, and discusses the accuracy of the estimates.

ESTIMATING RED SALMON ESCAPEMENTS BY SAMPLE COUNTS FROM OBSERVATION TOWERS

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The Kvichak River system of western Alaska is the foremost producer of red or sockeye salmon, *Oncorhynchus nerka* (Walbaum), for the Bristol Bay commercial fishery. Since 1955, a series of biological investigations on the red salmon of this system has been conducted by the Fisheries Research Institute of the University of Washington. A major aspect of the investigation has been to estimate the numbers of adult red salmon which compose the annual spawning escapement.

The method of estimation developed by the Institute involves systematic visual sample counts of the transient bands of migrants, taken in the main river after the fish have passed through the fishery and before they have dispersed throughout the spawning grounds. When the numbers of fish in the commercial catch are added, the total return can be determined. In addition, when the data are coupled with age analysis of scale samples from both the catch and the escapement, accurate estimates can be made of the number of adults in each age group returning from a given year of spawning and from a given year of seaward migration.

It is the purpose of this report to: (1) describe in detail the counting method, (2) summarize the counts from the years 1955 to 1959, and (3) discuss the factors influencing the estimation. The techniques discussed are the results of 5 years of research on the Kvichak.

This method of estimating a salmon escapement from tower counts made from observation towers in Bristol Bay, Alaska, was proposed by W. F. Thompson in the spring of 1953, and he organized the initial experiment on the Wood River in that same summer (Fisheries Research Institute, 1955; Thompson and Clancy, 1959). The success of this method prompted repetition the following year, with expansion to the Kvichak River system in 1955. In 1956 and 1957, the Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service, compared estimates from tower counts with those from the weirs on the Egegik River and found insignificant differences in total numbers of fish (Bureau of Commercial Fisheries, 1956 and 1957). In 1957, for the first time the escapements to all major red salmon streams in Bristol Bay were assessed from intermittent visual counts made from towers along the river banks.

The Kvichak River is about 57 miles long, draining from Iliamna Lake and following a twisting course through flat tundra country before flowing into Kvichak Bay (fig. 1). Its lower 43 miles is influenced by tides and the river has a mean depth of about 10 feet. From the head of tidewater, a broad area of numerous shallow channels called the Kaskanak Flats extends upriver 8 miles. From the flats to the outlet of Iliamna Lake, a distance of 4 miles, the river is restricted to a deeper channel that contains a few islands and gravel bars.

The system drains a watershed of 7,700 square miles, which includes a profusion of lakes and connecting or tributary streams. Iliamna Lake alone is 77 miles long and from 8 to 20 miles wide. Clark Lake, connected to Iliamna Lake by the Newhalen River, is 52 miles long and from 1 to 4 miles wide (U.S. Army Corps of Engineers, 1957). Extensive red salmon spawning grounds are distributed in streams, in spring ponds, and on beaches throughout the area.

As the Kvichak River empties into the ocean it is joined by first the Alagnak and then the Naknek River. These streams each sustain their own populations of red salmon, which mix as they arrive from ocean feeding grounds and encounter the commercial fishery in the Kvichak-Naknek district.

Note.—Approved for publication Jan. 30, 1961. Fishery Bulletin 192.

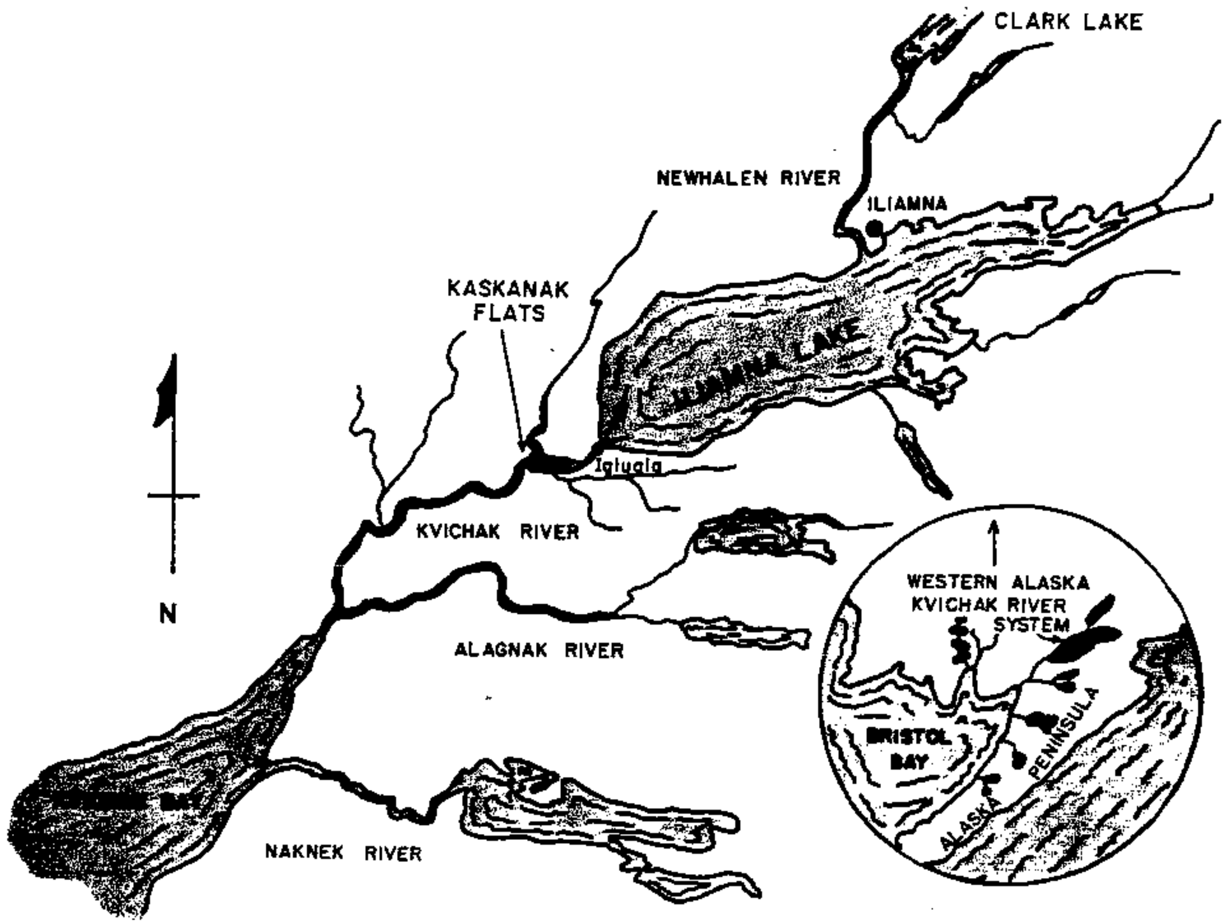

FIGURE 1.—Kvichak River system: one of the principal spawning areas for red salmon in the Bristol Bay region of western Alaska.

The Kvichak-Naknek district is one of several areas in Bristol Bay in which commerical fishing is permitted. The fishery came into large production at the turn of the century. Continuous catch and pack records since that time show tremendous fluctuations in abundance of red salmon from year to year. These fluctuations have formed a cyclic pattern with peak catches usually occurring every 4 or 5 years. From 1910 to 1958, the average annual catch was 9 million fish. The peak catch was taken in 1938 when 21 million red salmon were supplied to local canneries. Since 1938, however, the cycles tended to decline, and the catch reached a 60-year low of 923,000 fish in 1958.

Accurate estimates of escapements into the Kvichak River system are lacking for the years prior to 1955. In only one year was the entire escapement counted: in 1932, when the Bureau of Fisheries passed 5,065,000 salmon through a weir on the upper river (U.S. Bureau of Fisheries, 1933). Continued enumeration by weirs proved impractical because of excessive costs of construction and maintenance, hence, their use was discontinued.

Catches have been used in some areas as indices to escapements. But catches in the Kvichak-Naknek district include fish destined for the Kvichak, Naknek, and Alagnak Rivers, and to a lesser extent, the Egegik River. In addition, yearly changes in the distribution of gear, the intensity of the fishery, and contributions of the various runs, all vary the relation between catch and escapement. For these reasons, the catches are poor indices to red salmon escapements up the Kvichak River.

Estimates of the numbers of salmon on the spawning grounds, obtained from aerial surveys, have also been used as means of determining the escapements. However, detailed surveys of the numerous and widely distributed spawning areas of Iliamna Lake in the past 5 years have failed to reveal more than 20 percent of the estimated total Kvichak migration as determined from observation-tower counts. This percentage has varied from year to year; also the relative number of total spawners in each major spawning area has varied from year to year, irrespective of the size of the escapement. Hence, indices based on counts of spawning fish in the Kvichak River system appear to be highly unreliable.

METHOD OF OBSERVATION

The sample-count method of estimating escapements is based on the migratory habits of red salmon as they move up the river toward the area in which they originated. Salmon first appear in the Kvichak River the latter part of June and continue to pass upriver throughout July, with a migration peak occurring near the middle of the month. Once in the river the fish seek places where currents are reduced. Since areas of low currents are usually found near the bottom and next to the banks, the migrants follow restricted paths close to the shore where they can be readily observed. This habit is quite consistent in sections above tidewater where the river is confined to a single channel and where there are swift midstream currents.

It has been found that current velocities 6 inches from the bottom at the sites where the counts are taken range from 1.55 to 2.13 ft. a second, while those 6 inches from the surface range from 2.34 to 3.34 ft. a second. In 1959, the migrants passed upriver at an average relative speed of 1.52 ft. a second against the bottom currents.

Varying water levels influence the paths taken by the fish. Red salmon generally follow the banks more closely when the water level is high because of the relatively greater area of deep and quiet water close to shore. Kvichak water levels at the first of July have varied more than 2 feet from year to year, and usually rise from 8 to 14 inches during that month.

Fish appear in small separate schools when the size of the run is low. As the magnitude increases, the schools become larger and extend until the fish are passing in continuous bands. The separate schools behave somewhat erratically, but when the migration intensity is high the fish are less wary and follow the banks more closely. The direction of migration is usually continuously upriver. Only a few fish return downstream at the Kvichak counting site, and these occur invariably near the end of the migration. Slack water areas and sloughs are utilized by some individuals to rest. These fish commonly bear injuries from gill nets and predators in the ocean.

From extensive beach seining the Kvichak River escapements have been found to consist almost entirely of red salmon. Other species of salmon occur in the seine samples largely near the end of the migration, and make up less than 0.5 percent of the total escapements. The other species are omitted from the counts when identified from the towers, and therefore the possible error caused by including species other than red salmon is very small.

The visual counts are taken from towers erected at suitable locations, aided by use of background panels to silhouette the fish, turbulence reducers to smooth the surface, and other special counting aids. Once all migration paths can be observed clearly, it is relatively simple to count during sampling periods of predetermined length and to estimate the total escapement with a high degree of accuracy.

Tower Locations

The migratory habits of the fish and the physical characteristics of the Kvichak River limit the number of suitable sites for observation towers. The river below Kaskanak Flats is turbid and subject to tides that periodically reverse current flow. Migrants filter through the channels of the flats in numerous locations. Consequently, the most practical counting sites are limited to the area above the flats. The counting sites selected are near the outlet of Iliamna Lake close to the village of Igiugig and more than 50 miles upriver (fig. 1).

For peak efficiency, towers should be located where the moving bands of fish are constricted in width and pass without deviating from near the base of the structures. Since the river near Igiugig is split by an island, three towers are required (fig. 2). Towers No. 1 and No. 2 provide for sampling of the two primary paths in the main channel, which has a width of 380 feet and a maximum depth of about 16 feet. Tower No. 3

covers a shallow secondary channel through which the fish migrate when the water level is high. No fish passed through this secondary channel in 1957 and 1959 because of low water levels. The heaviest runs generally pass at tower No. 1 where a steep gradient and swift midstream currents tend to hold the salmon inshore where they pass in a narrow band. At tower No. 2, the gradient is more moderate and currents are reduced. Consequently, the fish spread over a broader area, particularly after the tower has been erected.

Tower No. 1 was constructed from spruce timbers on the right (west) bank of the river. Tower No. 2 was afloat, constructed of aluminum scaffolding and assembled on two skiffs which were lashed together and anchored off the right side of an island and on the left (east) side of the river (fig. 3). Tower No. 3 was also of aluminum scaffolding, and was located on the left (east) bank where the entire secondary channel could be observed.

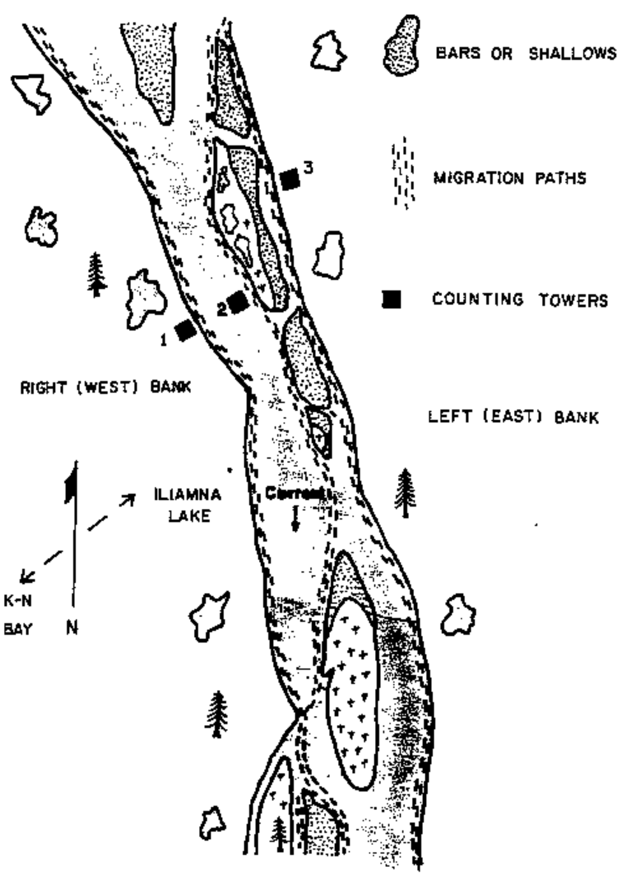

FIGURE 2.—Tower sites and paths of migrating fish on the Kvichak River, near Igiugig.

During sunny, calm days when the water is clear, salmon can be seen at any point in the river between towers No. 1 and No. 2. Only occasionally have they been seen near the middle and then never in a migrating band. Hence, we are confident that the salmon seen near the towers represent closely the entire migration passing at a given time.

Background Panels

Since fish blend with bottom contours making accurate counting difficult, panels were installed on the river bottom at the towers to silhouette the salmon passing. The blending is particularly camouflaging under conditions of semiturbid waters, overcast skies, and distorted river surfaces. The panels were painted a light gray to make the salmon visible under all but the most adverse conditions. As a rule, the fish will pass readily over any panel of dark or dull tones in preference to panels of bright tones. Such panels are particularly important for counting fish at night when artificial lights must be used.

In addition to revealing fish, panels must not startle the migrants, must be easy to install, and must resist deterioration in the current. Panels of 16-gage woven-wire screen of ¼-inch mesh have proved satisfactory. These panels are 3 feet wide, 10 feet long, and reinforced along the edges by 1-inch iron pipe (fig. 4). When placed in position, the panels extend out and downstream across the migration paths. Stakes of ¼-inch iron pipe, 18 inches long, are driven through metal loops to hold the panels in position.

Turbulence Reducers

Surface distortions resulting from rain, wind, waves, and bottom contours detract from accuracy of counting by reducing visibility. Turbulence reducers, an arrangement of boards and logs utilized to eliminate surging currents and wave action (fig. 5), are used to smooth the surface of the water over the panels so that the migrants can be readily seen. The wooden float is on the surface of the river immediately upstream from the panels and should not startle the fish by bobbing in the current or with vibrating anchor lines. Normally 4 feet of water is necessary before fish pass underneath undisturbed.

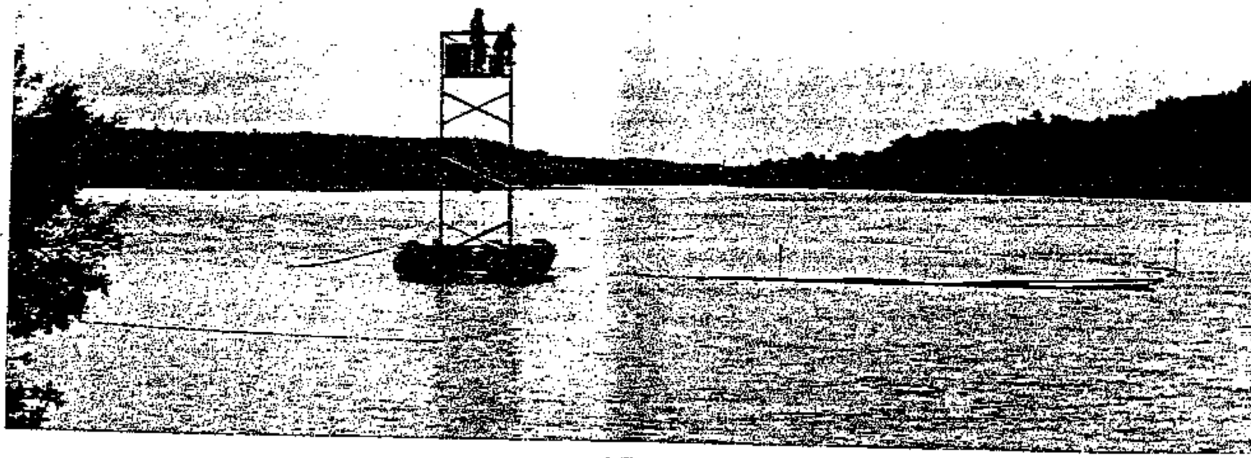

FIGURE 3.—Tower No. 2, the floating tower from which migrating red salmon were counted on the Kvichak River.

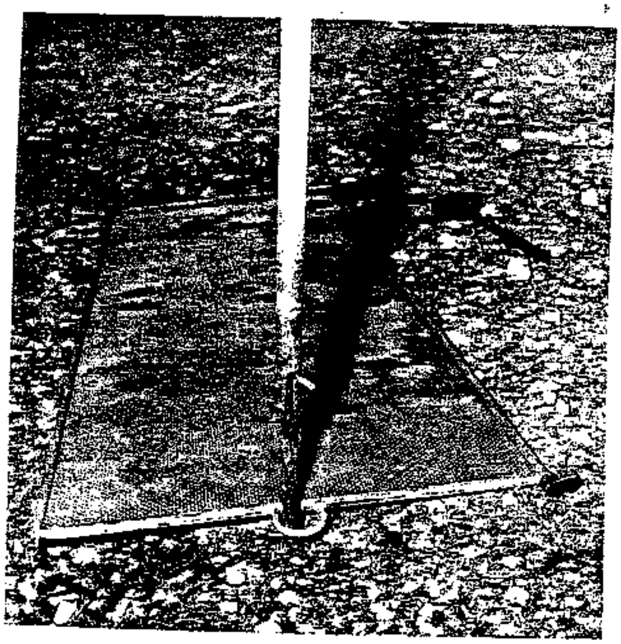

FIGURE 4.—Background panel used on river bottom to silhouette passing fish. Pin and driving rod in foreground. (Photograph by E. F. Marten.)

Three types of turbulence reducers have been used. The simplest was a log placed diagonally across the current. The second was a large V-frame, constructed from two or more timbers and placed with the apex upstream. The third and most efficient was a modification of the second, in which the effectiveness was increased by adding vertical pickets about 18 inches long and 3 inches apart to straighten subsurface currents. The latter type was originally developed and tested by the Fish and Wildlife Service on the Naknek River in 1957.

Experiments to improve visibility have also been conducted with a transparent plastic sheet which trailed on the surface of the water. The sheet smoothed the surface and did not disturb the migrants under moderate weather conditions, but rain, winds, and waves destroyed its effectiveness.

Counting Aids

Accuracy of counts was further increased by the use of (1) Polaroid glasses to reduce sun glare and surface reflection, (2) hand tallies to record

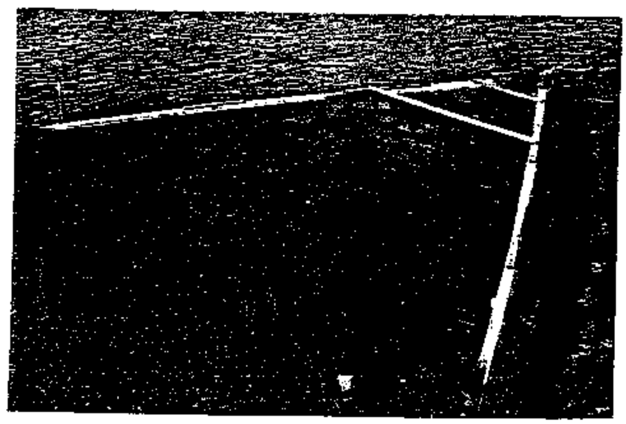

FIGURE 5.—A large turbulence reducer without vertical pickets smoothing an area 40 feet wide.

the migrants quickly and efficiently, (3) audible timers to limit the counting periods precisely and eliminate the need of watching a clock, (4) guiding devices to lead the migrants over the panels, and (5) spotlights to assist in night counts.

ESTIMATION OF THE RUNS

The sampling procedure was designed to obtain a reasonably accurate estimate of the total escapement while staying within the limits of both manpower and budget. Most of the information on which the initial sampling plan was formulated was known from previous observations of red salmon moving upriver and through weirs. Usually the major peak of the migration occurred in a day or two, although it was often preceded or followed by minor peaks. There were usually marked variations in numbers of fish from day to day and throughout a given day. In some locations near the fishery there were also marked changes in the numbers with the opening and closing of the fishing periods or with changing tides. It has since been noted at Igiugig on the Kvichak River that the heaviest runs usually appear along one bank at a time, with comparatively small numbers of fish passing along the opposite shore. The major path of the run changes erratically during the season and from year to year, but once a heavy run develops along one bank, it is usually maintained for several days.

A typical migration up the Kvichak River was counted continuously on July 16, 1955, in front of tower No. 1 (fig. 6). The fluctuations during

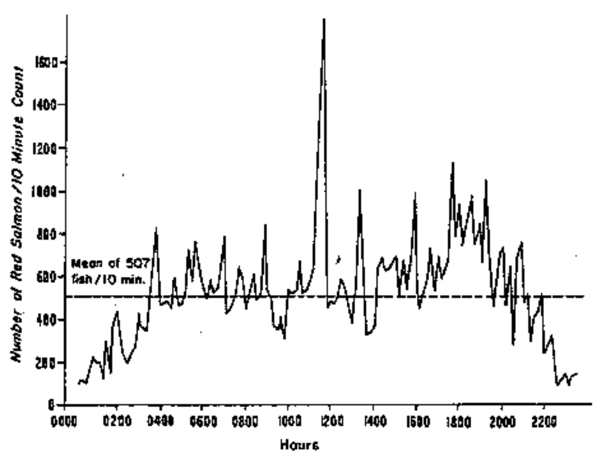

FIGURE 6.—Numerical fluctuations in migrating red salmon, from 10-minute continuous counts taken on July 16, 1955, at tower No. 1.

daylight ranged from about two-thirds of the mean of 507 fish each 10 minutes to about one and one-half times the mean. With such variations, it is desirable to sample every day and within each day to use a large number of short counting periods equally spaced in a systematic fashion.

Since the magnitude of the escapement fluctuates greatly, even in successive 10-minute counts, the estimates calculated from the samples are basically point estimates. A single count depicts accurately only the number of fish that happens to be passing at the time. Frequent counts depict accurately only the number of fish passing when the counts were taken, yet they are closely related to the total numbers in the fluctuating population. As a result, the daily estimates obtained from the counts approximate the numbers of migrating salmon, with the accuracy depending on the magnitude and frequency of the fluctuations and the frequency and duration of the sample counts.

Method of Sampling

The basic sample unit used in 1957, 1958, and 1959 consisted of 10-minute counts taken systematically each hour from each tower. The initial sample counts in 1955 were of 2 hours' duration and taken every 4 hours. In 1956, counts were eventually reduced to 40 minutes and were taken every 3 hours. But the 10-minute counts were found most practical to obtain and to use in calculating the estimate. Any sampling procedure will be improved if it is flexible enough to permit increases or decreases in the degree of coverage with the intensity of the migration. Consequently, at the beginning and end of the migration the counts were taken every 2, 3, or 4 hours. Also, at the peak of the migration or if a heavy run commenced along one bank, counts were increased to 15 or 20 minutes. This flexibility placed emphasis on increasing the accuracy of the total estimates by concentrating the counts on the periods with the heaviest escapements.

Counts were taken by natural light as early in the morning and as late at night as possible. The hours of darkness normally extend from 2300 to 0200, but often vary from day to day depending on the extent of sky overcast and the season. Accurate night counts depend on seeing the fish by means of artificial light from spotlamps. The intensity of these lamps was controlled by a rheostat; however, when the lights were sufficiently dimmed so that the salmon passed without hesitation, the counts were not so accurate as desired. Consequently, night counts were taken from only one tower in 1957 and not at all in 1958. In 1959, night counts were successfully obtained throughout the season by using a single, bright spotlight focused outside of the panels from the top of the towers. The fish passed in the dim area inshore from the spotlight and could be seen satisfactorily when crossing the background panels. Amber and red lenses were used experimentally in 1957 to determine whether the salmon would tolerate high illumination intensities when the lights were colored. The colored lights caused stronger avoidance reactions than dimmed white lights, and also were less penetrating in waters that were moderately turbid.

The tallying procedure varied with the intensity of the migration. Fish can be tallied separately when the number passing is fewer than 250 per minute. After the run exceeds this quantity, fish must be tallied by estimating groups of 10. Heavy runs requiring such grouped counts occurred only near the peaks of the larger escapements, such as the ones that occurred in 1956 and 1957.

Method of Calculation

The calculating procedure for estimating numbers of red salmon utilized the sample count as an estimator of the number of fish passing in a given unit of time. Therefore, with 10-minute counts taken hourly, the estimate of numbers of fish passing a tower is the product of multiplying the count by six. Daily estimates are the sum of calculated hourly estimates for all towers, and the seasonal estimate is the sum of all daily estimates.

Whenever systematic counts ceased at night or when the waters were turbid with sediment, the number of fish passing has been determined by averaging the counts preceding and following the periods with no counts. The estimate has been calculated by multiplying this average by the appropriate time factor.

Results

Estimates for Kvichak River escapements have varied widely from year to year, as would be expected from the cyclic nature of the runs and the changing intensities of the commercial fishery.

TABLE 1.—*Kvichak daily estimates of red salmon escapements, 1955 through 1959*

Date	1955	1956	1957	1958	1959
June 21	----------	----------	----------	----------	308
22	----------	----------	----------	----------	623
23	120	8	----------	0	307
24	256	38	----------	0	99
25	509	32	----------	0	212
26	166	30	7,337	24	914
27	211	88	4,987	29	416
28	38	263	2,922	58	1,133
29	90	229	9,305	515	440
30	112	343	55,827	582	1,098
July 1	186	311	51,797	174	588
2	148	311	62,332	1,485	384
3	102	373	82,789	960	1,152
4	151	11,280	60,394	153	7,872
5	3,426	10,256	70,371	129	49,612
6	24,364	63,063	48,245	48	51,288
7	9,125	75,851	45,703	29,328	48,780
8	657	134,163	83,275	161,109	30,758
9	893	221,055	56,435	148,760	12,524
10	918	268,179	133,815	44,945	19,097
11	12,766	268,048	269,310	24,802	32,627
12	11,851	375,393	858,194	3,575	21,285
13	6,937	498,944	461,961	2,241	52,818
14	5,458	583,882	871,154	3,966	88,226
15	21,578	694,874	147,430	43,458	90,994
16	73,304	923,007	88,426	47,559	55,343
17	31,822	1,053,583	56,012	5,946	23,398
18	13,398	910,574	30,330	1,530	16,093
19	5,726	711,050	49,258	879	17,357
20	4,146	650,430	72,705	1,017	18,225
21	4,781	606,643	37,966	2,673	9,140
22	4,537	440,420	26,820	834	5,637
23	3,972	288,795	23,152	2,130	5,631
24	2,245	212,571	25,612	2,274	3,801
25	2,187	154,609	14,537	999	1,514
26	1,073	98,495		357	2,119
27	962	66,923	[1] 34,409	543	2,189
28	785	87,516		938	2,592
29	797	25,100	----------	384	1,800
30	545	20,353	----------	381	390
31	409	15,999	----------	----------	[2] 6,216
Aug. 1	218	14,558	----------	----------	----------
2	82	5,676	----------	----------	----------
Total	250,546	9,443,318	2,842,810	534,785	680,000

[1] Estimate for July 26, 27, and 28 based on irregular daytime samples.
[2] Estimated late season migration.

These totals for the past 5 years were: 250,546 in 1955; 9,443,318 in 1956; 2,842,810 in 1957; 534,785 in 1958; and 680,000 in 1959.

Daily estimates for these years are listed in table 1, and a graphic comparison of the daily escapements thus obtained is presented in figure 7. The escapement of 1956 was the largest red salmon run ever counted moving upriver in Alaska. The escapement of 1955 undoubtedly was one of the smallest noted in the history of the Kvichak River system.

The significant part of the Kvichak River escapement has always passed the Igiugig towers within approximately 3 weeks (table 2). The peak varied from July 8–9 in 1958 to as late as July 17 in 1956. The end of the runs, defined as the points where the daily escapements are less than 1 percent of the final total, are relatively unimportant to the total estimates. Small numbers of fish usually continue upriver even after the counts are terminated. Earlier, before the counts commence in the

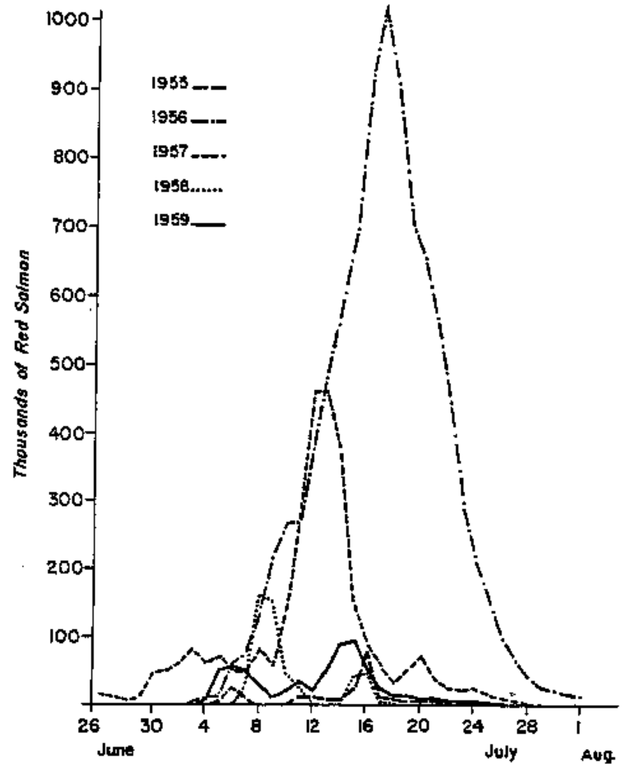

FIGURE 7.—Daily escapements of red salmon up the Kvichak River, 1955 through 1959.

spring, a few fish migrate upriver; adult red salmon have been reported taken in gill nets on upper Iliamna Lake as early as June 6.

There has been no apparent correlation between the duration and the size of the escapements. The main part of the small 1955 and the large 1956 escapements each passed in 19 days, and neither the start nor the end of the migration in the 2 years was more than 3 days apart.

FACTORS INFLUENCING VISUAL COUNTS

To a large extent, the accuracy of the basic sample counts depends on (1) individual counters, (2) migration intensity, (3) weather conditions, and (4) disrupted migration patterns. Once the relationships of these factors to the counts are recognized and understood, they can be taken into consideration in improving the counting method.

Errors Introduced by Individual Counters

Counting errors are known to result from individual differences in seeing, counting, and recording numbers of passing salmon. In 1957, 32 counts

TABLE 2.—*Size and timing of Kvichak red salmon escapements at Igiugig, 1955 through 1959*

Year	Size of escapement	Timing of 95 percent of the escapement			
		Start	Peak	Stop	Range (days)
1955	250,546	July 5	July 16	July 23	19
1956	9,443,318	July 8	July 16-18	July 26	19
1957	2,842,810	June 30	July 12-14	July 21	22
1958	534,785	July 7	July 8-4	July 17	11
1959	680,000	July 4	July 14-15	July 23	20

of 5 minutes' duration were taken by 2 observers counting simultaneously from the same tower. One counter (A) participated in all counts, while the other counter was taken from a group of three men designated XYZ. The data obtained are listed in table 3, where the difference in numbers of fish counted by XYZ is expressed as a plus or minus percentage of variation from A's count.

The range of variations between the 5-minute counts of A and one of the other three counters extends from −22.1 to +17.9 percent. By combining two consecutive counts to form standard 10-minute counts, the range is shortened from −7.8 to +10.7 percent. Further reductions occur when the counts are totaled and the differences calculated. For the two groups of 5-minute counts, the total differences are but +3.5 and −5.3 percent, respectively. The totals of all 32 counts differ by only −1.0 percent. Consequently, errors occurring in counts between paired observers, operating under a variety of observation conditions, tended to cancel out. Such counting errors, therefore, apparently occurred randomly and probably did not bias estimates of the escapement.

Errors Associated With Migration Intensity

As intensity of the migration increases, fish must be tallied more rapidly. An increase in migration intensity might indicate an increase in counting errors. The comparative data (fig. 8), however, show only a slight correlation between migration intensity and percentage of counting variation, even though greater variations in total numbers of fish counted did occur. This indicates that counts taken during increasingly heavy runs do not necessarily inject an increasing number of errors into the calculations.

The five comparative counts with extreme variations exceeding a plus or minus 10 percent ap-

TABLE 3.—*Comparison of counts during the same period by different observers*

1957	Tower No.	Time	Number of fish counted						Percentage variation		
			Counter A			Counters XYZ			5 min.	5 min.	10 min. (total)
			5 min.	5 min.	10 min. (total)	5 min.	5 min.	10 min. (total)			
July 9	1		63	9	72	66	9	75	+4.8	0.0	+4.2
11	1	1900		228	228		212	212		−7.0	−7.0
	2	1915	1,020	860	1,880	1,100	880	1,980	+7.8	+2.3	+5.3
12	1	1500	631	680	1,311	720	700	1,420	+14.0	+2.9	+8.3
	2	1515	700	600	1,300	650	620	1,270	−7.1	+3.3	−2.3
	1	0715	306	659	965	327	574	901	+6.9	−12.9	−6.6
13	3	1020	960	950	1,910	1,020	740	1,760	+6.3	−22.1	−7.8
14	1	0900	688	745	1,433	658	703	1,361	−4.4	−5.6	−5.1
	2	0915	487	510	997	574	530	1,104	+17.9	+3.9	+10.7
	1	1700	760	653	1,413	755	560	1,315	−0.7	−14.2	−6.9
	2	1715	413	440	853	395	443	838	−4.4	−0.7	−1.7
15	1	1900	93	76	169	92	75	167	−1.1	−1.3	−1.2
	2	1915	280	285	565	276	285	561	−1.4	0.0	−0.7
16	1	1700		70	70		67	67		−4.3	−4.3
	2	1715	190	94	284	190	98	288	0.0	+4.3	+1.4
17	1	1700	86	50	86	34	48	82	−5.6	−4.0	−4.7
	2	1715	18	106	124	18	99	117	0.0	−6.6	−5.6
Total			6,645	7,015	13,660	6,875	6,643	13,518	+3.5	−5.3	−1.0

peared when the migration passed 450 fish per 5-minute interval, but even these errors followed a random pattern and tended to average out. However, because of the greater magnitude and importance of these errors, it is imperative to increase the number of samples taken with an increase in intensity of the run. This greatly increases the reliability of the calculated estimates.

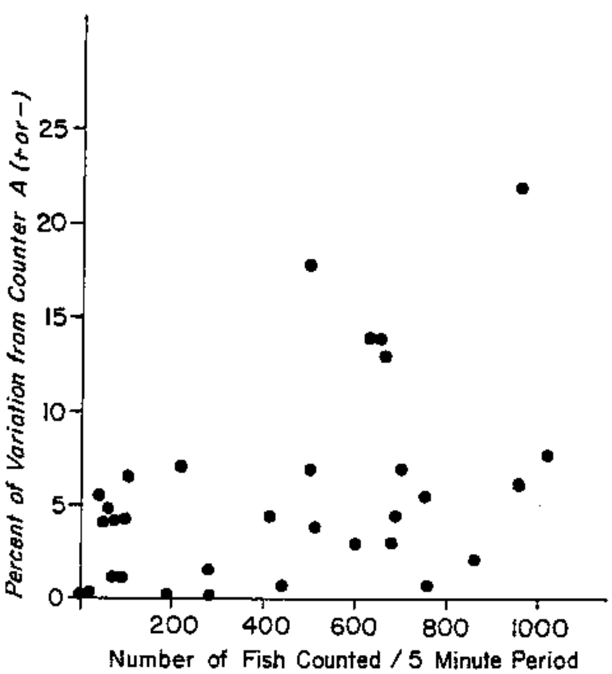

FIGURE. 8.—Relation between migration intensity and variations between counters.

When extremely heavy runs occur and samples must be obtained by estimating groups of 10 fish, counting errors are undoubtedly greater than when individual fish can be tallied. Heavy runs requiring such counting procedures are infrequent and usually occur past one tower at a time. On the Kvichak River, such runs appeared only during the intense 1956 escapement (July 11–21) and briefly in 1957 (July 12–14).

Effect of Weather Conditions

Sun glare, overcast skies, wind, and rain lower visibility and increase the difficulties of obtaining accurate sample counts. Glare may be troublesome during a 4-hour period daily when the sun is bright and low over the water. Overcast skies impart a dull appearance to the surface of the water, while upriver winds and rain disturb the surface and thereby distort the outlines of objects under the surface. The effects of these adverse conditions, combined with the normally turbulent water surface, make turbulence reducers essential. Then, with the aid of Polaroid glasses, the observers can count the passing fish accurately at almost any part of a given day.

Moderately turbid water, which occurs irregularly throughout the season, is the most important factor affecting the accuracy of the counts. This turbidity is the result of heavy breakers against the beach at the outlet of Iliamna Lake, which occur with strong east winds. The pounding causes excessive amounts of silt to be suspended in the water which then flows downriver and reduces visibility at the tower sites. Occasionally the point is reached where counts are not possible. This is discussed as high turbidity, under the section on "Accuracy of the Estimates."

When the water is moderately turbid, the variation between comparative counts might be expected to increase. Yet the data presented in table 4 show that the variation between comparative counts taken in moderately turbid water was less (+1.7 percent) than those obtained in clear water (−3.0 percent). This suggests that moderately turbid water did not increase the counting variation between two counters. It does not indicate that both counts were as accurate in turbid water as in clear water, especially on the fringe areas of the migration paths.

Effect of Disrupted Migration Pattern

Migration past a tower is momentarily disrupted as the fish scatter into deep water when the skiff bearing the counter arrives. While the fish soon re-form their ranks and resume an apparently normal migration pattern, it is possible that commencing the counts as soon as the counter is ready would inject directional errors.

A test of the timing of the counts to the time of the counter's arrival was made in 1957 by comparing the first and second 5-minute counts of 841 samples (table 5). In most instances these counts were started as soon as the counter had tied the skiff, climbed the tower, and readied his equipment, a period of 1 or 2 minutes. Since the first count was higher than the second almost one-half the time, i.e., neither consistently higher nor lower, the counts were probably not biased. The time required in preparation to commence the counts, therefore, is evidently sufficient for the migration to assume a normal pattern.

TABLE 4.—*Effect of turbid water on count variation*

Counter	Number of fish counted in—					
	Clear water			Moderately turbid water		
	1st 5 minutes	2d 5 minutes	Total	1st 5 minutes	2d 5 minutes	Total
A	3,988	3,988	7,976	2,657	3,027	5,684
XYZ	4,078	3,658	7,735	2,797	2,986	5,783
Percent variation	+1.3	−8.1	−3.0	+5.3	−1.4	+1.7

ACCURACY OF ESTIMATES

Estimates of the total migration are subject to statistical error because of periods when the continuity of the sample counts is interrupted, and because of fluctuations in abundance of fish from one counting period to another. At present we can only guess at possible bias that may accrue because of interruptions in the counts, but we can estimate precisely the possible statistical error for fluctuations of abundance. For example, it is possible to calculate confidence limits for each annual escapement to determine the reliability of the sampling program. In addition, various mathematical tests can be applied to determine the effects of changes in the length of the samples and the interspacing periods.

Effect of Interruptions in the Counts

Interruptions in counting have occurred because of high turbidity when no fish can be seen, also because of darkness, especially before satisfactory lighting was developed.

Highly turbid water occurred 10.9, 3.7, 3.1, 6.2, and 5.5 percent of the time in the years from 1955 to 1959, respectively. Once the river becomes turbid it normally remains in that condition for at least 24 hours, because the water takes about 8 hours to clear after the east wind ceases. The periods when high turbidity prevailed, in relation to the magnitude of the escapement each year, are shown in figure 9. Only in 1957 did the water turn highly turbid when a heavy migration of red salmon was passing the towers.

Beach seine hauls have been obtained occasionally to provide relative indications of migration intensity in turbid waters. These hauls are probably more effective in turbid than in clear water because of inability of the fish to see the net. Yet, catches were low, indicating a low migration intensity. A systematic comparison of hauls in clear and in turbid water was made in 1958, where the average catch per haul along the right bank was compared with the estimated number of fish migrating past tower No. 1 (fig. 10). The curve formed by this relationship indicated that few fish were migrating in the highly turbid water. Therefore, calculations of the migration for the period of turbid water, based on an average of low counts immediately preceding and following the turbid period, were basically correct.

TABLE 5.—*Relation of 1st 5-minute counts to 2d 5-minute counts, Kvichak River, 1957*

Category	Counter									Total
	A	B	C	D	E	F	G	H	I	
1st count (high)	56	83	54	88	42	57	6	5	26	417
2d count (high)	43	82	46	89	49	61	8	10	36	424
Number times counted	99	165	100	177	91	118	14	15	62	841
Percent 1st count high	56.6	50.3	54.0	49.7	46.2	48.3	42.9	33.3	41.9	49.6

Night counts were not taken in 1958 because of difficulty in counting the fish and the questionable accuracy of counts made under floodlights. Instead, estimates were made on the assumption that the migration was constant between the last evening count and the first morning count. The total time lost to sampling by omitting night counts each day was 4 hours, 2300—0200. Estimates of the escapements based on systematic night counts in 1957 and 1959 from tower No. 1 were compared with those calculated by averaging the 2200 and 0300 samples (table 6). In both instances the escapements test-calculated by omitting night counts were high, 6.8 percent for the larger 1957 run and 34.6 percent for the smaller 1959 run. Consequently, it is necessary to obtain night counts whenever possible to maintain a high degree of accuracy in the estimates.

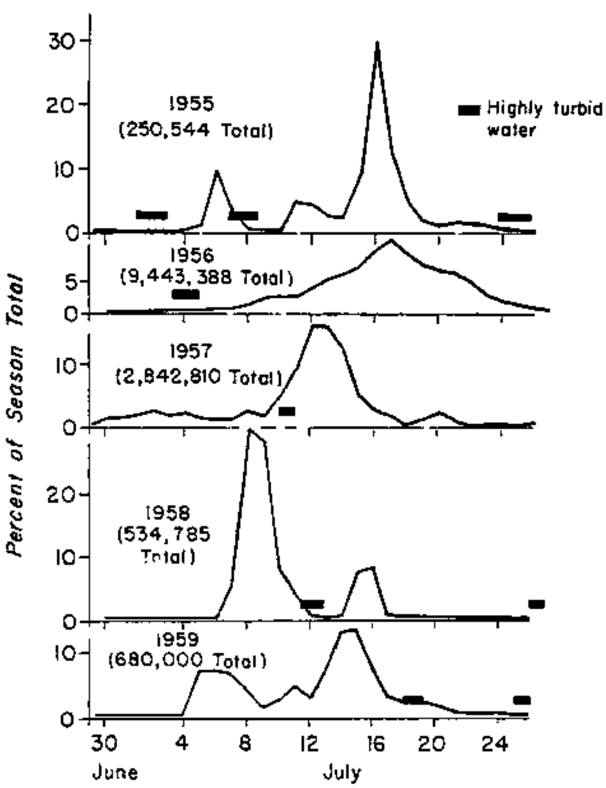

FIGURE 9.—Relationship of periods of high turbidity to red salmon escapements, Kvichak River, 1955 through 1959.

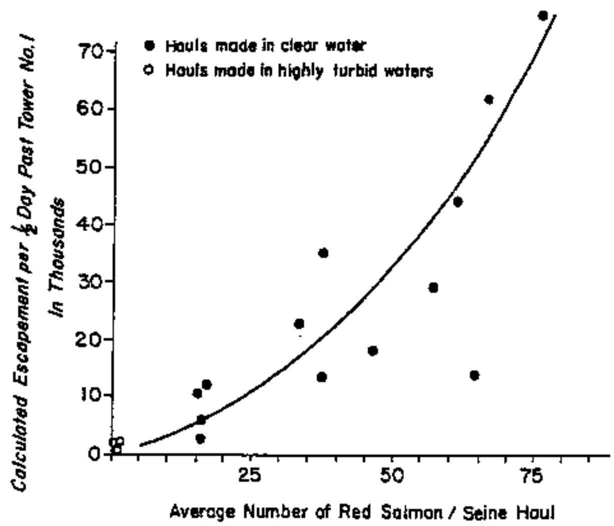

FIGURE 10.—Relation between average numbers of red salmon caught per seine haul and the calculated number of fish passing tower No. 1. Data computed on a ½-day basis, Kvichak River, July 7–17, 1958.

Population Fluctuations

Fluctuations in numbers of migrating fish from season to season, from day to day, and from hour to hour, are characteristic of Kvichak River salmon runs. Seasonally, the fluctuations have ranged from ¼ to 9½ million fish. Daily fluctuations were clearly defined in small escapements, less defined in large runs.

However, fluctuations taking place between counts are of the greatest importance to the estimates of the escapement. The greater the frequency and magnitude of fluctuations from one sample to the next, the more the calculated estimates are likely to deviate from the true population passing upriver. Fluctuations from sample to sample and between samples are the result, to a large extent, of the schooling habits of the fish. These schools are particularly noticeable when the migration intensity is low, but even during a heavy run wide fluctuations in numbers continue to occur.

TABLE 6.—*Determination of possible error from omitting all night counts from tower No. 1, 1957 and 1959*

Year	Night estimate		Percentage error by method B	Percentage error in daily estimates
	A. By expanding hourly samples (used)	B. By averaging 2200 and 0300 samples (tested)		
1957	198,441	211,944	+6.8	+1.4
1959	51,454	69,240	+34.6	+6.9
Total	249,895	281,184	+12.5	+2.5

The width of the confidence intervals associated with a point estimate is influenced directly by the fluctuations in numbers of fish. The width of such intervals can be decreased by an increase in sampling time, especially by increasing the number of samples but also by expanding the length of the sample unit.

Confidence Limits of the 1959 Escapement

Confidence limits were determined for point estimates of the annual red salmon escapements.[1] The method was applied to the 1959 counts to illustrate the procedures and to point out the accuracy achieved by the present sampling methods. The counts were of 15 minutes' duration and were taken every 4 hours early in the season. A change to 10-minute counts taken hourly was made on June 29 as the migration increased. Daytime counts were increased to 15 minutes, some to 30 minutes or more each hour, near the peaks of the escapement. Then all counts were reduced to 10 minutes and taken every 4 hours near the end of the run.

Before confidence limits can be calculated, the season must first be stratified, since the variance in the counts is associated with the mean numbers of fish for each segment of the escapement (table 7). The total migration season from which the four strata were drawn extended from noon, June 21 to August 1, a total of 39.5 days. This is equivalent to 79 days of total counting for the two towers. As intended by the sampling plan, an increase in the percentage of sampling time occurred with each strata in proportion to its numerical importance; 7.8, 14.1, 22.1, and 24.8 percent with strata I to IV, respectively.

It is assumed that the sample counts were taken randomly throughout each stratum regardless of some extended counts or occasional gaps and were, therefore, representative of the stratum from which they were taken. The preliminary calculations for the determination of the confidence limits are summarized in tables 7 and 8, where—

N=total number of sampling units (10-minute counts).

P=total fish passage (population).

N_i=total number of sampling units in the ith stratum.

n=total number of samples (10-minute counts) obtained.

n_i=total number of samples obtained in ith stratum.

X_{ij}=number of fish in jth sample in ith stratum.

$\overline{X_i}$=mean number of fish per sample in ith stratum from—

$$\overline{X}_i=\frac{\sum_j X_{ij}}{n_i}$$

S_i^2=variance of the samples in ith stratum from—

$$S_i^2=\frac{\sum_j X_{ij}^2-\frac{\left(\sum_j X_{ij}\right)^2}{n_i}}{n_i-1}$$

Each stratum is weighted by $W_i=\frac{N_i}{N}$. The weighted mean ($\overline{\overline{X}}$) and the associated variance $S^2_{\overline{\overline{X}}}$) are then calculated from—

$$\overline{\overline{X}}=\sum_{i=1}^{4}\overline{X}_i\cdot W_i=60.62,\text{ also}$$

$$S^2_{\overline{X}_i}=\frac{S_i^2}{n_i}\cdot\frac{N_i-n_i}{N_i},\ S^2_{\overline{\overline{X}}}=\sum W_i^2\cdot S^2_{\overline{X}_i}$$

[1] The principal procedures have been used previously by O. A. Mathisen in analysis of Wood River escapement estimates: A Stratified Sampling Program for Visual Tower Counting, 1957. University of Washington, Fisheries Research Institute, Seattle (Wash.). Manuscript. Modifications in this procedure for application to Kvichak River data were made with the assistance of C. O. Junge, Jr., of the Fisheries Research Institute.

TABLE 7.—*Stratification of the Kvichak escapement in 1959*

Strata	Average number fish counted [1]	Date and site of escapement in stratum	Number sampling units (N_i)	Number samples obtained (n_i)	Percent n_i
I	0–20	All units from June 21 to July 30 other than noted.	6,912	540	7.8
II	20–80	Tower No. 1: July 4, 8, 10, 12, 18, 19, 20, 21, 22. Tower No. 2: July 12, 17, 18, 21, 22.	1,872	264	14.1
III	80–220	Tower No. 1: July 6, 7, 11, 17. Tower No. 2: July 5, 6, 7, 8, 9, 10, 14, 16.	1,728	382	22.1
IV	260–500	Tower No. 1: July 5, 13, 14, 15, 16. Tower No. 2: July 15	864	214	24.8
			N=11,376	n=1,400	

[1] Determined as 10-minute counts for uniformity of calculation.

The final calculations of the confidence limits, with the level of significance set at 95 percent (t=1.96), are made from—

$$(\overline{P}, \underline{P}) = N\left[\overline{\overline{X}} \pm t_{.05}\sqrt{\sum (W_i^2)\left(\frac{S_i^2}{n_i}\right)\left(\frac{N_i - n_i}{N_i}\right)}\right]$$

$$= 11{,}376\left[60.62 \pm 1.96\sqrt{S_{\overline{\overline{X}}}^2}\right]$$

$$= 689{,}613 \pm (11{,}376)(1.96)(\sqrt{1.5213})$$

$$= 689{,}613 \pm (22{,}297)(1.233)$$

$$= 689{,}613 \pm 27{,}492$$

As calculated, the 95-percent confidence limits for the 1959 Kvichak River escapement are equivalent to ±3.99 percent (±27,492) of the 689,613 estimated total fish passage (P). Such narrow limits point to the effectiveness of the sample-count estimation program in current use.

The sum of the daily estimates given in table 1 (680,000) differs slightly from the estimate calculated from the stratified data. The tabulated value is considered the best estimate, and is well within the calculated confidence limits.

Effect of Changing the Sampling Design

The length of the counting period and the frequency of the samples are the two main variables to be considered in formulating a sampling program. Increasing or decreasing either one influences the reliability of the calculated estimates.

To analyze these variables, systematic test samples were drawn from a continuous 48-hour count obtained in 1955. The lengths of the counting period of the samples tested were 10, 20, 30, 40, and 60 minutes, while the sampling frequencies were 1, 2, 3, and 4 hours. Generally, four different tests were made with each relationship: sample period length to sample frequency. Totals of the calculated estimates were then compared with the actual total for the 48-hour period, and the percentage deviation plotted in figure 11.

The percentage of error tends to drop with an increase in the length of the samples and with an increase in the frequency of the samples. Short counts, under 40 minutes in length, provide reliable calculations when taken every 1 or 2 hours, usually ranging within a plus or minus 6 percent. These counts show a much wider range of error when taken every 3 or 4 hours. This indicates that, for a specific reduction in counting time, the most consistent results would be obtained with short samples taken frequently. The 1955 and 1956 estimates, based on infrequent larger samples, may have been less accurate than those in recent years. However, in 1955, 73 percent of the escape-

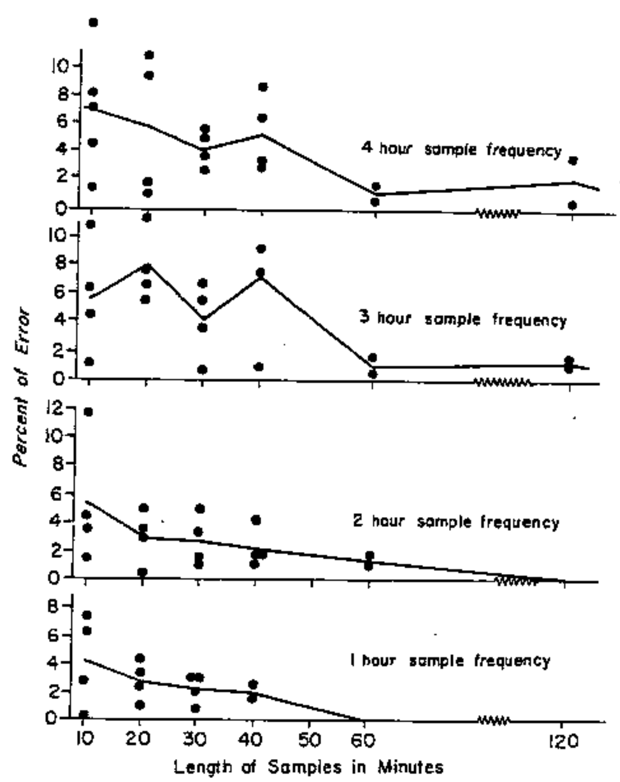

FIGURE 11.—Distribution of sampling errors with various sample period lengths and frequencies.

TABLE 8.—*Preliminary calculations for the determination of confidence limits for the 1959 Kvichak escapement*

Strata (i)	Weights		$_i\Sigma X_{ij}^2$	$_i\Sigma X_{ij}$	$\overline{X}_i$	S_i^2	$\frac{N_i - n_i}{N_i}$	n_i	$W_i^2 S_{\overline{X}_i}^2$
	W_i	W_i^2							
I	0.6076	0.369,178	84,686	3,160	5.9	122.8	0.922	540	0.0774
II	.1646	.027,093	1,385,388	13,995	53.0	2,446.7	.859	264	.2157
III	.1519	.023,074	12,684,729	56,027	146.7	11,725.4	.779	382	.5524
IV	.0760	.005,776	32,187,143	73,290	342.5	33,272.4	.752	214	.6758
Total	1.0001								$S_{\overline{X}}^2 = 1.5213$

ment was enumerated in a continuous count. In 1956, the variation in number of fish from sample to sample was low, evidently because of the greater magnitude of the run. The basic sampling design of 10-minute counts taken hourly and supplemented by longer counts during a heavy run, therefore, appears to be highly efficient.

It is difficult to determine with any degree of precision the most efficient sampling design, since the size and nature of the migration vary from year to year. Such factors as the proper distribution of time, manpower, and equipment in obtaining accurate counts must also be considered. On the Kvichak River, short frequent counts have proved practical to obtain adequate estimates under all operating conditions.

SUMMARY

1. A method of estimating red salmon escapements by using systematic sample counts was developed and used on the Kvichak River, Alaska, from 1955 to 1959 by the Fisheries Research Institute.

2. The method was based on the fact that migrating red salmon avoid swift midstream currents and pass upriver in narrow bands close to the shores, where observation towers, background panels, turbulence reducers, and other counting aids could be used to obtain accurate counts.

3. Statistically, migrating red salmon were considered as a fluctuating finite population. The design of the sampling procedure was aimed at obtaining a reasonably accurate estimate of the total run from properly distributed visual counts throughout the migration season.

4. The basic sample unit consisted of 10-minute counts taken systematically each hour from each tower. This design was varied to provide increased or decreased coverage with the corresponding variations in the intensity of migration.

5. Estimates for a given period of time were obtained by multiplying the sample count by the appropriate factor. For longer periods when no samples were obtained, the estimates were interpolated by averaging the counts preceding and following the gap and multiplying by the appropriate time factor.

6. Daily estimates were calculated as the sum of all estimates for all towers each day, and the final escapement estimate was the sum of all daily estimates.

7. Kvichak River escapements, as estimated by the sample count method, amounted to 250,546 fish in 1955; 9,443,318 fish in 1956; 2,842,810 fish in 1957; 534,785 fish in 1958; and 680,000 fish in 1959.

8. The accuracy of each sample count was affected by different counters, migration intensities, weather conditions, and disrupted migration patterns. However, the factors were not found to inject significant directional errors but showed definite tendencies to cancel out.

9. The accuracy of the calculated estimates was affected by interruptions in the continuity of the counts from highly turbid waters and darkness and by fluctuations in numbers of fish between samples.

10. A method of determining confidence limits was illustrated. Applied to the 1959 Kvichak River escapement, the confidence limits were established at a plus or minus 3.99 percent at a 95 percent level of significance.

11. The calculated estimates were influenced by varying the lengths and frequencies of the samples. The percentage of error tended to drop with an increase in the length of the samples, and with an increase in the frequencies of the samples. Samples less than 40 minutes in length were found to provide estimates usually within a plus or minus 6 percent of error when taken every 1 or 2 hours.

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Informational Leaflet 101

THE USE OF EXPANDED TEN-MINUTE COUNTS AS ESTIMATES OF HOURLY SALMON MIGRATION PAST COUNTING TOWERS ON ALASKAN RIVERS

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ABSTRACT

Data collected during the 1965-66 seasons at the counting towers on eight Alaskan rivers was analyzed to evaluate the use of 10-minute counts per hour as the basis for estimating the magnitude of the hourly migration, and hence, the daily and seasonal migration of salmon returning to spawn. In general, relatively large errors between the hourly estimates (based on 10-minute counts) and the hourly counts (assumed to be the hourly migration) could be tolerated if these errors were unbiased and tended to cancel out over the duration of the season.

The relative errors between the sample total hourly estimates and total hourly counts ranged from -34.9% to +21.8%. These errors were equally divided between over-estimates and under-estimates. The arithmetic mean relative error of +0.9% was not statistically different from zero at the 95% level. The 95% confidence interval for the mean relative error was (-7.1%, + 8.9%).

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Juneau, Alaska

I. INTRODUCTION

In managing a commercial salmon fishery to obtain maximum sustained yield, one of the most important single pieces of information which must be obtained each year is an estimate (either total or index) of the number of salmon migrating up a river or stream to spawn. This annual estimate of escapement not only represents the number of parent spawners allowed to propagate the species, but, when combined with the annual commercial catch to produce the total annual return, it provides the basis for evaluating the success or efficiency of a given parent spawning population.

The problem of enumerating spawning populations of salmon has been approached in a number of different ways: W.F. Thompson (1962) gives a short review of some of the different methods experimented with in Alaska for enumeration of salmon. These include direct surveys (either aerial or by foot) of the spawning grounds, weirs, mark-recovery, etc. Each method was plagued with disadvantages such as excessive cost, lack of precision, inconsistency in estimates from year to year, etc. In the early 1950's, as a result of observing the phenomena of sockeye (Oncorhynchus nerka) salmon migrating in narrow bands along the banks of clearwater rivers in Bristol Bay, counting towers were set up on the Wood River. Figure I illustrates the type of tower presently being utilized in Bristol Bay. The success of these first towers as a means of enumerating migrating salmon resulted in the expanded use of counting towers. At present, escapements to ten rivers in Bristol Bay (cf. Figure 2) are enumerated through the use of counting towers. Less than five percent of the sockeye spawning in Bristol Bay must be estimated by aerial and/or foot surveys of the spawning grounds. In addition, counting towers have received limited use in other parts of Alaska. Although sockeye are the primary species of salmon enumerated through the use of counting towers, there are several instances where other species have also been successfully enumerated by the same method. In particular, counting towers may be used effectively on small, shallow rivers such as the Kwiniuk River in Norton Sound even though the salmon, primarily

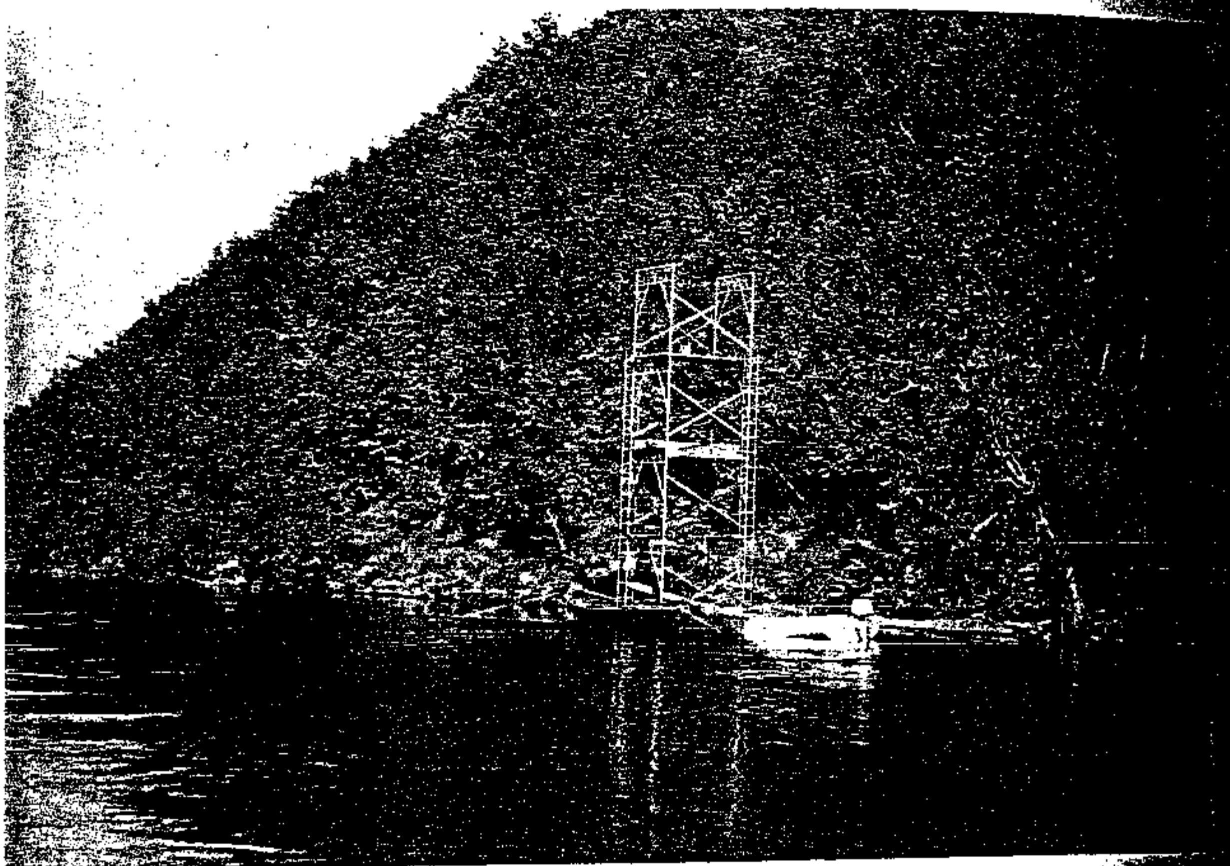

Figure 1. Counting tower presently in use on the Wood River, Bristol Bay, Alaska.

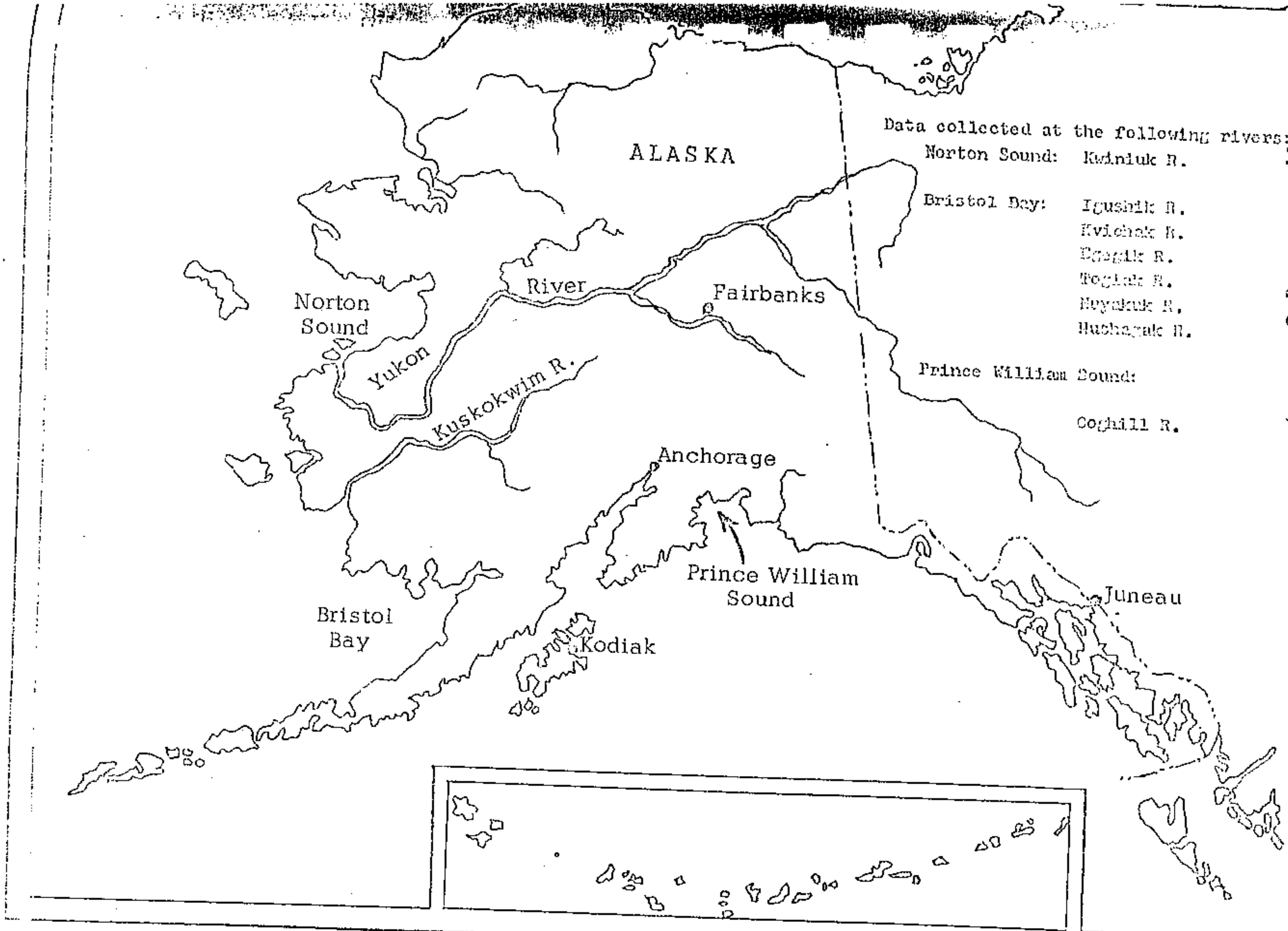

Figure 2. General locations of Alaskan rivers at which counting tower studies were conducted.

chums (O. keta) and pinks (O. gorbuscha), do not migrate in the same "band" pattern exhibited by the sockeye in Bristol Bay. In addition to providing estimates of annual escapements, the counting towers also provide a valuable check on the accuracy of aerial surveys, which are extremely important to the management of the Alaskan salmon fisheries.

Counting towers do not provide error-free estimates of the escapements to the individual rivers. Some errors may be introduced by 1) deviations from the "band" pattern of migration which result in fish failing to pass close enough to the tower to be observed, 2) poor visibility as a result of adverse weather and/or water conditions, and 3) large migration rates which necessitate estimating (by 10's, 100's, etc.) the number of fish passing by the tower. However, in general the degree of accuracy of escapement estimates obtained through the use of counting towers is comparable with the accuracy of other biological data collected and used to describe the population dynamics of the salmon stocks.

Studies were conducted in 1956-57 by the Fish and Wildlife Serv (Rietze, 1957, Spangler and Rietze, 1958) to compare the counts obtain by counting towers with those obtained from weirs. On the Egegik Riv 1956 an estimated 984,908 fish passed the counting tower as compared wi 1,063,877 salmon counted through the weir during the sampling period. This represents a -7.4% relative error in the tower estimate with respec to the weir estimate. In 1957 an estimated 712,124 salmon passed the counting towers while 631,001 were estimated to have passed the weir during the sampling period. This represents a +12.9% relative error in the tower estimate with respect to the weir estimate. These studies indicated that the majority of the salmon travel in the shallow water near the banks of the river (in an effort to escape the main current) and, therefore, can be counted from towers situated on or near the banks with acceptable levels of accuracy.

Due to cost considerations only limited personnel can be placed a the counting towers on each river, and since these personnel are also required to conduct other studies such as sampling adult salmon for age weight-length data, smolt enumeration, etc., it is desirable to reduce the actual time spent counting fish as much as possible without introducing undesirable errors. On the basis of the early studies by Fisheries Research Institute and the U.S. Fish and Wildlife Service (Becker, 1962, Rietze, 1957), it was decided that counts made 10 minutes out of each hour and expanded appropriately would provide adequate estimates of the hourly migration.

Because of the importance of obtaining accurate estimates of escapement, and since the use of counting towers has been extended to more riv in Alaska, it was decided to re-evaluate the use of ten-minute counts as the basis for estimating the hourly migrations and, hence, the total annual escapement. Special concern was for those systems with small escapements.

which often exhibit very erratic patterns of migration. The development of runs to these smaller systems can help return salmon production in Alaska to the higher levels exhibited in the early years of the fisheries.

II. EXPERIMENT DESIGN AND COLLECTION OF DATA

The primary objective of this study was to evaluate the use of hourly ten-minute counts as the basis for estimating hourly migration, and hence, total seasonal migration. In general, the accuracy of the hourly estimates is of interest only in respect to the effect it has on the accuracy of the seasonal estimates of escapement as obtained from the cumulative sum of the hourly estimates. In other words, a significant amount of relative error could be tolerated for the individual hour counts if these errors tended to cancel out and produce only small relative errors in the total season estimates.

The primary data collected consisted of hour counts obtained by making six consecutive ten-minute counts. The first ten-minute count was then multiplied by six to obtain an estimate of the hourly migration which was to be compared with the total hour count. In the remainder of this report, these two estimates of the hourly migration will be termed "hourly count" and "hourly estimate" to distinguish between the estimate obtained by counting for the entire hour and the estimate obtained by multiplying the ten-minute count by six. For the purpose of this report, the hourly counts will be assumed to be the actual number of salmon migrating past the counting tower during that hour.

In addition to the actual tower counts, weather and water conditions were also recorded. Figure 3 illustrates the form used to record the collected data.

In order that the data collected would be representative of the variable conditions encountered on Alaskan rivers, data was collected during both the 1965 and 1966 seasons from six rivers in Bristol Bay, one in Norton Sound and one in Prince William Sound. The approximate location of these rivers is shown in Figure 2. Thus, the data collected represents tower counts obtained under a wide variety of weather and water conditions, river types and migration rates. In some instances, chum and pink salmon were also counted.

In general, the hourly counts were obtained during the season as time permitted as it was not feasible (or necessary) to make total hour counts for the entire season. However, in 1966 the large number of hourly counts made on the Kwiniuk River necessitated sub sampling these counts to simplify the computations required for analysis. The first 36 counts were chosen with the restriction that only those total hour counts greater than 50 were chosen. This restriction was made to prevent a large number

Alaska Department of Fish and Game

Location

Page 1

DATE			OBSERVER	WEATHER, ETC.	
MO	DAY	YR	INITIALS	SKY	WIND
2	4	6	9		

TOWER SITE	TIME		SALMON COUNT					TOTAL COUNT
BANK 13	HR 15	MIN 15	RED 20	CHUM 24	KING 28	COHO 32	PINK 36	
		1						
		2						
		3						
		4						
		5						
		6						

TOWER SITE	TIME		SALMON COUNT					TOTAL COUNT
BANK	HR	MIN	RED	CHUM	KING	COHO	PINK	
		1						
		2						
		3						
		4						
		5						
		6						

TOWER SITE	TIME		SALMON COUNT					TOTAL COUNT
BANK	HR	MIN	RED	CHUM	KING	COHO	PINK	
		1						
		2						
		3						
		4						
		5						
		6						

TOWER SITE	TIME		SALMON COUNT					TOTAL COUNT
BANK	HR	MIN	RED	CHUM	KING	COHO	PINK	
		1						
		2						
		3						
		4						
		5						
		6						

Remarks

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of very small counts (including zero) from occurring in the sample. Total hour counts were made throughout the 1965 and 1966 seasons on the Kwiniuk River and were used for comparison with escapement estimates based on aerial surveys.

III. BASIC DATA AND RESULTS OF ANALYSIS

The basic data collected in the form of hourly estimates (ten-minute counts multiplied by six) and hourly counts (counts made for the entire hour) is given in Appendix Tables A-1 through A-12. For the Kvichak and Egegik Rivers the data is given separately for the left and right bank towers for the sake of comparison; however, for the other rivers the data for both banks was combined to obtain adequate sample sizes. Counts are given by species except in the case of the Coghill River counts, where conditions did not allow accurate separation by species.

Sample sizes (i.e., number of total hour counts) varied from a minimum of 12 on the Igushik River in 1965 to 80 on the Coghill River in 1965. Total sample counts varied from 1,187 sockeye counted at the Togiak tower in 1966 to 585,700 sockeye counted at the Kvichak left bank tower in 1965. Average hourly migration rates (total fish counted divided by number of hours counted) during the sampling period varied from 24 fish per hour on the Nuyakuk River in 1966 to 17,630 fish per hour on the right bank of the Kvichak River in 1965.

A summary of the data collected for each system is given in Table 1. For the sake of illustration, the data collected from the Egegik River in 1965 is graphed in Figure 4.

Analysis

Regression analysis was applied to the data given in Appendix Tables A-1 through A-12. Analysis of variance tables are given in Appendix Table B-1. To circumvent the assumption of a bivariate normal population, which is necessary if the sample correlation coefficient r is to be used as an unbiased estimate of the population correlation coefficient ρ, the coefficient of determination r^2 was calculated to provide a measure of the linear relationship between the hourly estimates and the hourly counts. The resulting values are given in Table 1. These values vary from a minimum of 0.464 (Kwiniuk River, 1966) to a maximum of 0.986 (Nuyakuk R., pinks, 1966). The geometric mean coefficient of determination $r^2 = 0.733$ indicates that, on the average, approximately 70% of the sum of squared deviations of the hourly estimates is explained by the hourly counts (which were assumed to be the actual migration relative to the hourly estimates).

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Table 1. Summary of 1965-66 Counting Tower Data and Analysis

Year	System	Species	Sample Size 1/	Total Sample Count 2/	% of Total Migration Counted 3/	Ave. Hourly Migration Rate 4/	Coeff. of Determination	Coeff. of Variation	Relative Error 5/
1965	Kwiniuk River	Chum	53	6,302	19.4	119	0.630	1.5	+10.6
		Pink	35	1,249	14.4	36*	0.575	1.8	+ 8.6
	Igushik River	Sockeye	12*	2,700	1.5	225	0.676	1.4	-34.9*
	Kvichak River								
	Left Bank	Sockeye	36	585,700*	2.4	16,270	0.872	0.5	- 4.7
	Right Bank	Sockeye	22	387,950	1.6	17,630*	0.707	0.4*	- 3.1
	Egegik River								
	Left Bank	Sockeye	24	24,820	1.7	1,034	0.968	1.7	+13.4
	Right Bank	Sockeye	23	43,281	3.0	1,882	0.810	1.3	+ 1.3
	Coghill River	Mixed 6/	80*	14,974	29.6 7/	187	0.558	0.7	-10.1
1966	Kwiniuk River	Chum	36	7,295	22.0	203	0.464*	0.9	- 5.3
		Pink	36	5,213	48.0*	145	0.575	0.7	- 0.8
	Togiak River	Sockeye	15	1,187*	1.3	79	0.935	1.5	+21.8*
	Nuyakuk River	Sockeye	24	16,494	10.2	687	0.893	1.7	+ 0.6
		Pink	32	12,361	0.9*	386	0.973*	2.2*	+16.3
	Nushagak River	Pink	14	34,028	(0.9*) 7/	2,430	0.897	1.3	- 1.1

* Indicates maximum and minimum values for each column.

1/ Number of total hour counts.

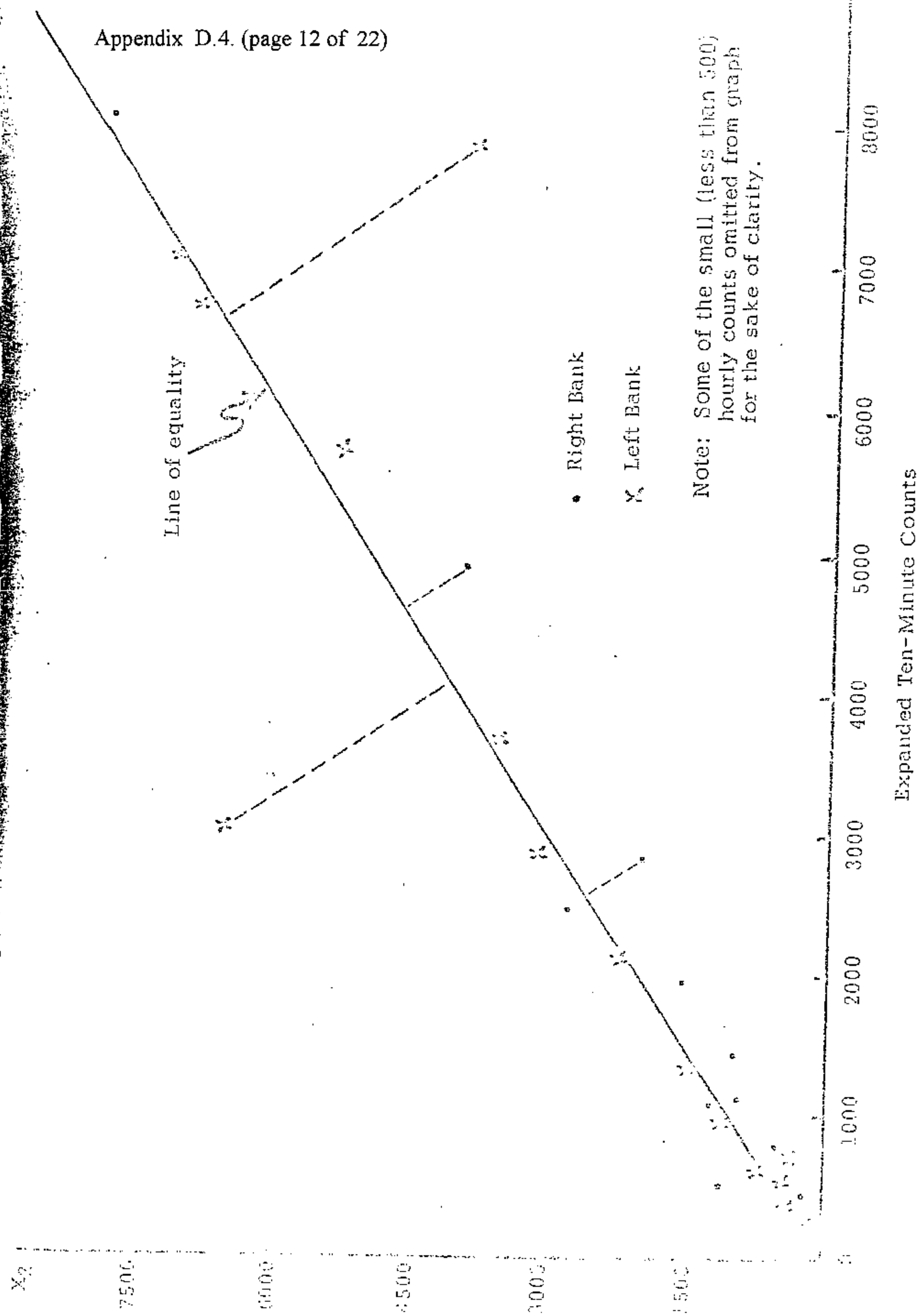
2/ Total salmon counted during sample hours.

3/ Percent of total season migration counted during the sample hours.

4/ Total sample count ÷ sample size.

5/ Relative Error = 100 [illegible] (Hourly Estimates) [illegible] Σ (Hourly Counts)] ÷ Σ (Hourly Counts)

6/ [illegible] chums and sockeye counted.



Line of equality
Right Bank
Left Bank
Note: Some of the small (less than 500) hourly counts omitted from graph for the sake of clarity.
Expanded Ten-Minute Counts
1000
2000
3000
4000
5000
6000
7000
8000
1500
3000
4500
6000
7500

If one is allowed the freedom of accepting the assumption of a bivariate normal population, the values of r, used as estimates of the population correlation coefficients, indicate significant (i.e., 95% level) correlation between the hourly estimates and hourly counts for rivers.

Although the above correlation between the hourly counts and hourly estimates is of interest in that it does indicate good correlation these two variables, as mentioned above, the primary concern is with the agreement between the sum of the hourly estimates and the hourly counts over the season. The relative errors occurring in the individ hourly estimates (relative to the hourly counts) may be statistically nificant in some cases; however, if these relative errors occur without bias, then the sum of the hourly estimates will provide an unbiased mate of the sum of the hourly counts. To express this more concisely we have

$$Y_i = X_i + \varepsilon_i$$

where

Y_i = the hourly counts, i.e. the hourly

X_i = the hourly estimates, and

ε_i = the error with which Y_i is estimated

and if ε_i is randomly distributed with mean zero, then if we sum Eq over all possible counts,

$$\Sigma Y_i = \Sigma X_i + \Sigma \varepsilon_i$$

i.e.,

$$\Sigma Y_i = \Sigma X_i$$

since $\Sigma \varepsilon_i = 0$ i.e., the seasonal sum of the hourly estimates will prov an unbiased estimate of the seasonal sum of the hourly counts.

To investigate whether $\bar{\varepsilon} = 0$, the relative error was calculated each set of data. The results are shown in Table 1.

The relative error between the total hourly estimates and the to hourly counts varied in absolute value from 0.6% (Nuyakuk R., sockeye 1966) to 34.9% (Igushik R., 1965) with a geometric mean of 5.1%. How ever, two comments should be made regarding these relative errors:

1) The relative errors are equally divided between positive (over-estimates) and negative (under-estimate) errors with seven over-estimates and seven under-estimates. Further more, the arithmetic mean (used so the algebraic signs of the error could be included) is +0.9%. This value is not statistically different (at the 95% level) from zero.

This indicates that no directional error (i.e., bias) is occurring in the sum of the hourly estimates.

2) It should be noted that, in eleven of the fourteen samples, less than one-fourth of the total seasonal migration for any one river was counted during the sampling period. Moreover, the average sample size of 31.7 (hours) is less than the number of hours contained in 1.5 days, whereas the total migrations are generally enumerated during a period of not less than 30 days. Thus, a seasonal migration estimate would generally consist of the sum of approximately 700 individual hour estimates, or more than twenty times the number of hours contained in the average sampling period for this study. If, in fact, the error of estimate (between the hourly counts and hourly estimates) is unbiased as indicated, the error between the sum of the hourly counts and the hourly estimates would be expected to be less when the sum is taken over the entire season than when the sum is just over the sampling periods.

At this point it may be instructive to concentrate our attention on the data collected from the Igushik River (1965) and the Togiak River (1966) as these samples reflected the largest relative errors, viz. − 34.9% and +21.8% respectively. In both cases, sockeye salmon were being counted. The following points are of interest:

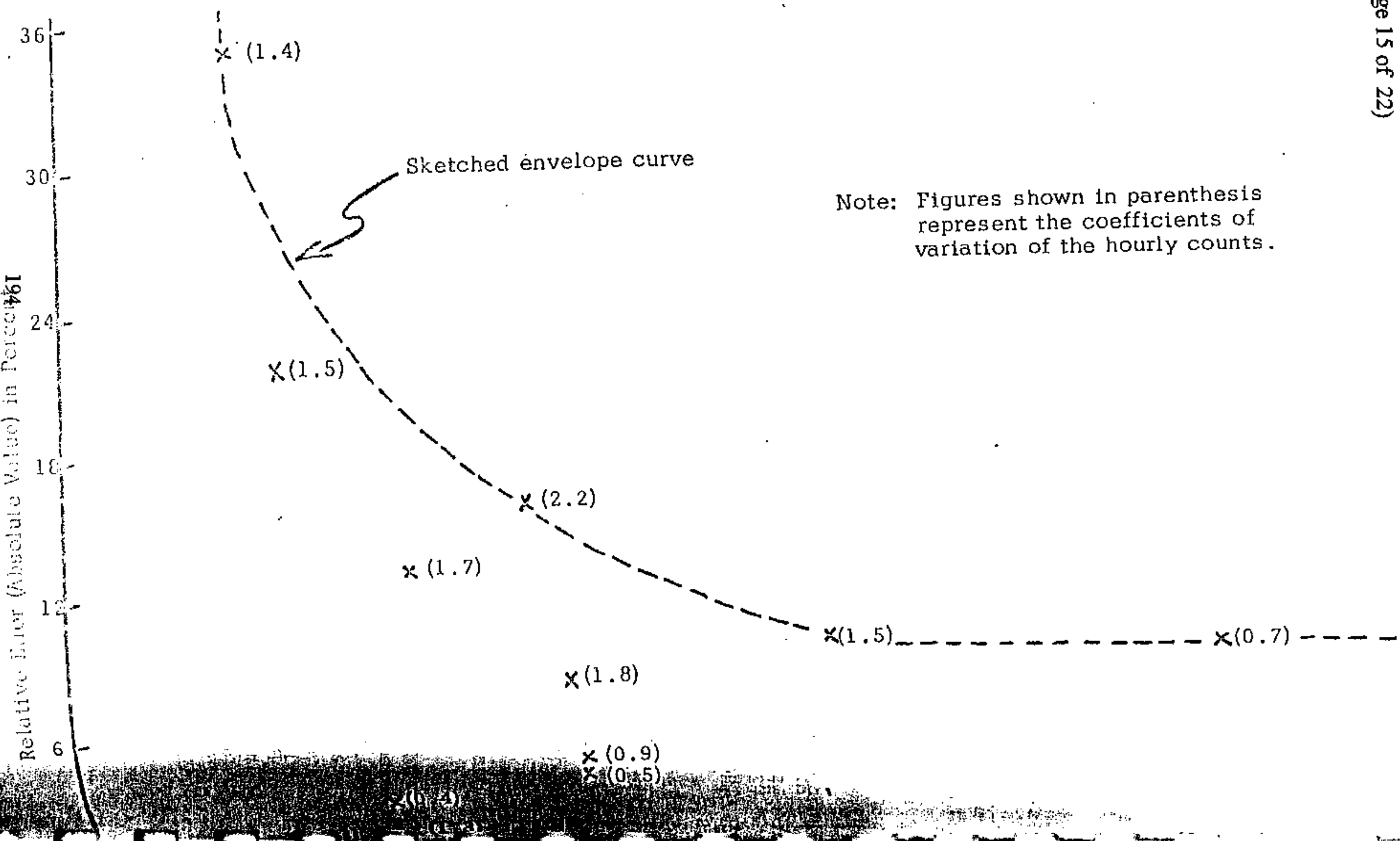
1) Of the fourteen samples, the Igushik and Togiak samples represented the smallest and third smallest sample sizes respectively. In the Igushik sample, 2 hours accounted for 81% of the variation, while in the Togiak sample 3 hours accounted for 70% of the variation.

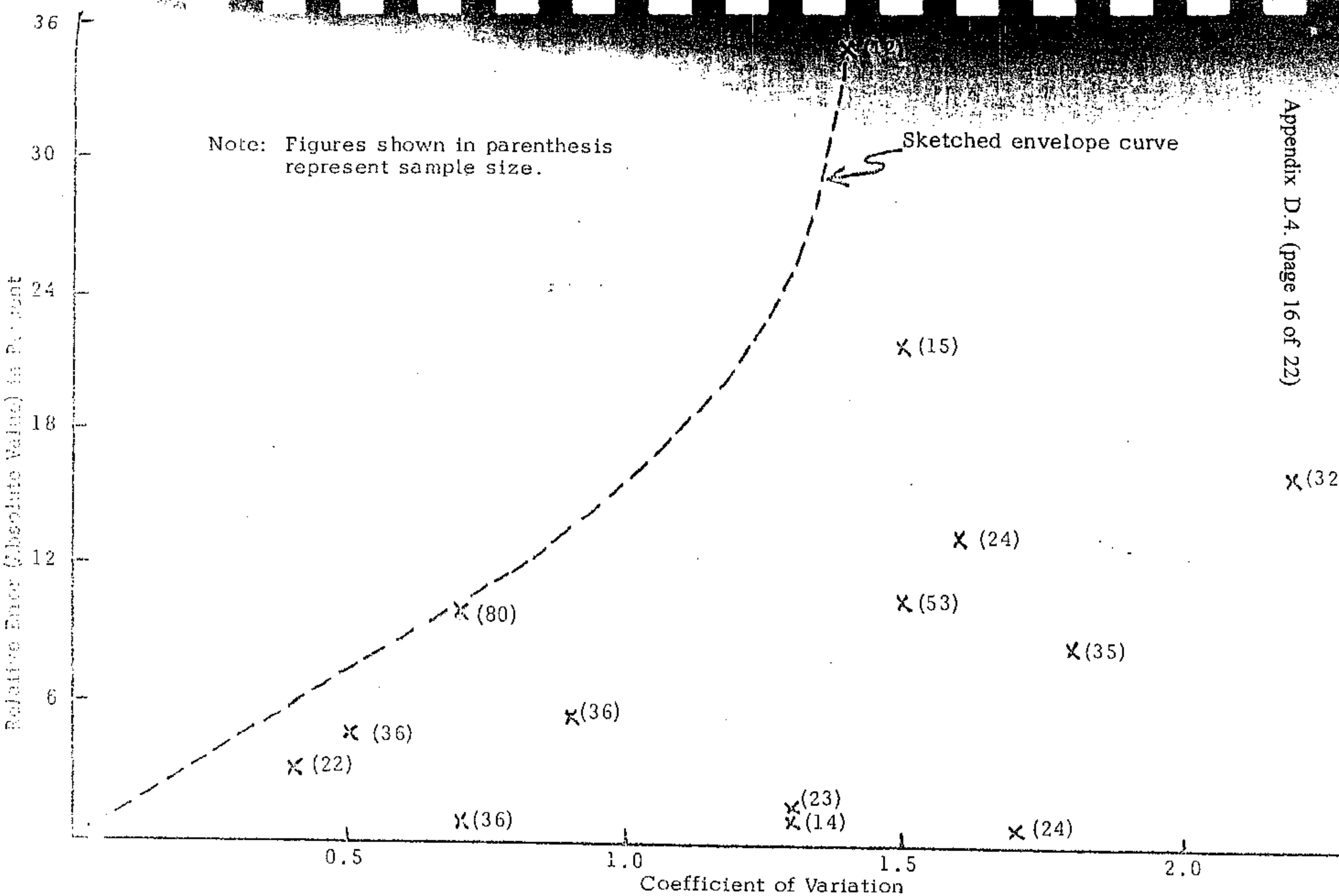
2) The Igushik and Togiak samples represent the second and third smallest percentages of the total season migrations counted during the sampling periods.

3) If we express the variations of the hourly counts within a sample as the coefficient of variation (i.e., the ratio of the standard deviation to the mean), the Igushik and Togiak samples represent respectively the fifth and fourth largest coefficients of variation recorded.

It appeared, therefore, that the relative error between the sum of sample hourly estimates and hourly counts depended on the sample size (which directly represents a measure of the percentage of the total seasonal migration counted during the sampling period) and the variation of the hourly counts within a sample. To investigate this, the relative error was plotted against the sample size (Figure 5) and the coefficient of variation (Figure 6).

Figure 5. Relationship between relative error in total hourly estimates and sample size.





Note: Figures shown in parenthesis represent sample size.
Sketched envelope curve
Relative Error (Absolute Value) in Percent
36
30
24
18
12
6
0.5
1.0
1.5
2.0
Coefficient of Variation
(15)
(32)
(24)
(80)
(53)
(35)
(36)
(36)
(22)
(23)
(14)
(36)
(24)

The important point to observe in Figures 5 and 6 is that the variation in the relative error decreases as the sample size increases and the coefficient of variation decreases. Although this is not equivalent to saying that a small sample size and/or a large coefficient of variation will result in a large relative error, it does imply that the chances of a large relative error occurring are greater under these conditions. In practical terms, this means that escapement estimates for short-term periods (i.e. less than several days) may be expected to exhibit significant relative errors in some cases. The chances of a significant relative error are also increased if the migration is very erratic, i.e., if the coefficient of variation is large. Conversely, however, the relative error can be expected to be small over long-term (e.g. one month) periods, especially if the migration is not excessively erratic.

A situation which could result in a significant relative error even though escapement estimates were for a period of approximately one month would be one similar to that occurring on the Ugashik River in 1963. Durin[illegible] the 1963 season, 47% of the seasonal escapement passed the Ugashik counting tower in one day, i.e., on July 15, 181,000 sockeye were esti[illegible] mated to have passed the tower, while the final season total was 388,[illegible] The next largest day's escapement was 43,000 on July 18. A large rela[illegible] error occurring in the estimate for July 15 may not be cancelled by the [illegible] occurring in the smaller estimated escapements for the other days. (How[illegible] ever, it should be noted that a 30% relative error for the July 15 estim[illegible] would represent only a 14% relative error for the season). The Ugashik [illegible] is rather unique relative to the other Bristol Bay rivers which do not ex[illegible] such a high degree of concentration in the escapement patterns. Fur[illegible] the escapement patterns for the Ugashik system generally do not exhi[illegible] extreme degree of concentration existing in the 1963 migration.

For the purpose of analyzing the relationship between the rel[illegible] error, the sample size and the coefficient of variation, multiple regr[illegible] analysis was applied to the data. It was assumed that the relative [illegible] was directly proportional to the coefficient of variation and inverse[illegible] portional to the square root of the sample size. The following rela[illegible] was obtained:

$$Y = -6.90 + 7.024\,X_1 + 2.064\,X_2$$

where X_1 = 10 X the inverse square root of the sample size

X_2 = the coefficient of variation, and

Y = the relative error

However, the sum of squared deviations $\Sigma(Y-\hat{Y})^2$ from Eq[illegible] 16% less than the sum of squared deviations from the mean, indi[illegible] the sample size and coefficient of variation alone do not explain the variations in the relative errors.

Again, if we are allowed the freedom of assuming random sampling from a tri-variate normal distribution, the partial correlation coefficients $r_{X_1Y \cdot X_2} = 0.344$ (d.f. = 11) and $r_{X_2Y \cdot X_1} = 0.159$ (d.f. = 11) do not represent significant correlation between the relative error and the inverse square root of the sample size (with the coefficient of variation considered constant) or between the relative error and the coefficient of variation (with the sample size considered constant).

The data shown graphically in Figures 5 and 6 and the results above indicate that sufficient conditions for small, i.e., acceptable, relative errors are a large sample size (i.e., hourly estimates for period of approximately one week or more) and non-excessive variations in the hourly escapements. Although a small sample size and/or large coefficient of variation increase the chances of a large relative error, these conditions do not <u>necessarily</u> imply a large relative error.

Since the sample size (i.e., number of hours) and coefficient of variation for a given season cannot be controlled, the next logical step to increase the accuracy of the hourly estimates would be to increase the time counted each hour. The following table illustrates the effect of increasing to 20 minutes the time counted each hour. For this purpose, only those systems with the four largest (in magnitude) relative errors are considered.

	RELATIVE ERROR	
SYSTEM	10-MINUTE COUNTS	20-MINUTE COUNTS
ushik River, 1965	-34.9%	-6.6%
gegik River, 1965, Left Bank	+13.4	+9.8
Togiak River, 1966	+21.8	+9.9
uyakuk River, 1966, Pink Salmon	+16.3	+5.2

In each case, counting for twenty minutes of each hour reduced the relative error to less than 10%. This suggests that in the event that extreme variations occur in the hourly counts during the season, if a high degree of concentration occurs in the migration pattern, if the migration occurs in a very short period or if short period estimates are desired for the purpose of comparison with aerial surveys, counting time per hour should possibly be increased to 20 minutes. In this manner the relative error would very likely remain under 10%.

As a final method of determining what range of relative errors one might expect if sampling is conducted in the same manner as in this report, we calculate the confidence interval associated with the mean of the relative errors given in Table 1. As seen from Figure 7, the distribution of

Figure 7. Frequency Distribution of Relative Errors, Counting Tower Data, 1965-66.

this relative error is approximately normal. The confidence interval for the mean is given (Cochran, 1963) by

$$\overline{X} - t_{1-\alpha/2,\ n-1}\ s/\sqrt{n} \leq \mu \leq \overline{X} + t_{1-\alpha/2,\ n-1}\ s/\sqrt{n}$$

where $\overline{X}$ = mean relative error,

μ = true mean

t = Student's "t" statistic

s = sample estimate of the standard deviation

n = sample size.

For α = .05, n = 14 we have $t_{1-\alpha/2,\ n-1} = 2.160$.

Thus, we have

$$0.9 - (2.16)\ (3.69) \leq \mu \leq 0.9 + (2.16)\ (3.69)$$

i.e.,

$$-7.1 \leq \mu \leq 8.9$$

Therefore, the 95% confidence (or, more correctly, fiducial) interval for the mean relative error is (-7.1%, + 8.9%); i.e., if sampling is conducted in the same manner as described in this report, then in 95 times out of a 100 the true mean (relative error) will be contained in the interval (-7.1%, + 8.9%).

IV. CONCLUDING REMARKS AND RECOMMENDATIONS

In conclusion, the data in this report indicates that, in general, relative errors of less than 10% occur in the seasonal estimates of the number of migrating salmon as a result of using 10-minute counts made from counting towers to estimate hourly migration. It should not be implied that each hourly estimate (based on a 10-minute count) enjoys the same degree of accuracy (relative to the true hourly migration) as does the seasonal sum of hourly estimates (relative to the seasonal migration). However, the fact that the errors in the hourly estimates occur without bias results in a cancelling of these errors in the total seasonal estimate of the migration.

Some situations may occur in which counting time per hour should be increased to 20 minutes to insure acceptable levels of accuracy. Some examples where 20-minute counts per hour may be desirable are:

a) If short period escapement estimates (obtained from counting towers) were to be compared with aerial survey estimates, hourly 20-minute counts would more exactly estimate salmon migrating during the period in question.

b) If counting is to be discontinued during certain portion of the day to free the personnel for other duties, 20-minute hourly counts made for the remaining portion of the day could be used to estimate the total daily migration.

c) If a highly concentrated migration pattern is anticipated, 20-minute hourly counts could be made for the period of peak migration to increase the probability of obtaining seasonal migration estimates containing less than 10% relative error.

V. ACKNOWLEDGEMENTS

The author wishes to express his appreciation to the following Alaska Department of Fish and Game biologists who were responsible for collecting the data used in this report: Ronald Regnart and Mike Geiger (Arctic-Yukon-Kuskokwim), Ken Middleton, Angus Robertson, Michael L. Nelson and Steven Pennoyer (Bristol Bay), and Robert Roys (Prince William Sound). The 442 hours spent under not always pleasant conditions by the biological aides who manned the counting towers is also appreciated.

The above biologists also reviewed the original manuscript and made numerous pertinent suggestions.

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