CHAPTER 3

Karluk River Weir

At last! Accurate counts of spawning salmon.

For the first 39 years of commercial fishing on Karluk River sockeye salmon (1882–1920), federal managers responsible for regulating the fishery and assuring that adequate numbers of fish reached the spawning grounds were at a severe disadvantage. From the fishery's earliest years, they knew the number of salmon being harvested and packed at nearby canneries, but they did not know how many were spawning in and near Karluk Lake. Managers tried to regulate this fishery without knowing how many sockeye salmon actually escaped the fishery. They understood that adequate numbers of fish must spawn each year to perpetuate future runs, but they lacked a definite measure of the yearly reproduction. Even rough estimates were lacking because direct observations of spawning sockeye salmon at Karluk Lake were rare before 1919. Estimates of escapement numbers were further complicated during 1896–1916 because sockeye that eluded the commercial fishery then migrated through Karluk Lagoon where many were taken for hatchery brood stock.

Although officials and employees of the early canneries also realized that sufficient numbers of sockeye salmon must spawn each year, apparently no one tried to estimate the numbers that migrated upstream. Only rarely is it noted in the historical Karluk literature that cannery personnel visited Karluk Lake to see the sockeye's spawning grounds, though company officials often worried that the then-abundant salmon runs might decline. Most likely, some visits did occur in the early years, but these were uncommon events and produced no gauge of spawning escapements. Instead, cannery personnel focused their attention and energy on the sockeye salmon harvests at the lower Karluk River and ocean waters off Karluk Spit, not on the spawning grounds at Karluk Lake:

> The men at the head of the canneries know the cannery business thoroughly. They know how to get the fish to the canneries, pack them, case them for market, and figure on the profits, but it is exceptionally rare to find one who had followed even his home stream to its source and examined the lake system and the spawning grounds. . . . The cannerymen are in the country for fish and not for investigation or scientific research. (Moser, 1899)

Ingwald Loe, APA hatchery superintendent in 1910, visited Karluk Lake several times, possibly to evaluate it for a new hatchery site. He incorrectly claimed that "fully two thirds of the salmon spawn in the lake itself, chiefly along the northeastern shore. . . the lake feeders do not carry many spawning fish, not being big enough or of suitable bottom."[1] Likewise, Moser, then an APA official, briefly reached Karluk Lake's outlet during this same period, but not having a boat, he explored no further (U.S. Senate, 1912). Perhaps one possible reason why cannery officials generally lacked an intense interest in the spawning grounds at Karluk Lake was their firm belief that the modern hatchery on Karluk Lagoon, which operated from 1896 to 1916 and released millions of fry, would be a major support to future runs of sockeye salmon.

Federal regulations on fishing times, places, and gear were enacted in the early years of Karluk's fishery, but these laws were based on qualitative judgments of what might allow sufficient numbers of fish to escape the fishery. Often, in practice, the regulations were poorly enforced or the fishermen and canneries ignored or found ways around them. Typically, the fishing and cannery operations were unmonitored for nearly the entire season, the government inspector usually visiting Karluk's canneries for one day each year. Canneries operated under self-imposed fishing rules in some early years, and rival companies closely monitored each other's actions for compliance. Moser (1899) declared in 1897 that "the laws and regulations pertaining to Alaska salmon fisheries are very generally disregarded, and that

[1] Fassett, H. C. 1910. Report on the salmon hatchery operated by the Alaska Packers Association on Karluk Lagoon, Kadiak Island, Alaska. Unpubl. report. 25 p. Located at Alaska Historical Collections, Alaska State Library, Juneau.

they do not prevent the illegal capture of fish." Yet federal regulatory officials apparently believed that sockeye salmon escapements to Karluk Lake were adequate prior to 1921 because laws restrained the harvest and fishery inefficiencies allowed sufficient fish to enter the river.

But the once-famous runs of Karluk River sockeye salmon had greatly declined by 1920, and it was obvious that the number of fish reaching the spawning grounds must be accurately known in order to scientifically manage this resource. This conclusion was reached, in particular, by the renowned fishery biologist Charles H. Gilbert of Stanford University, along with several USBF officials, including Henry O'Malley, Field Agent; Ward Bower, Chief Agent of the Alaska Fisheries Service; and Hugh Smith, Commissioner of Fisheries. To accurately measure the number of sockeye migrating to the spawning grounds, they installed a salmon counting weir across the Karluk River in 1921 and operated it between May and October. By collecting these weir data for a number of years, they reasoned that a definite relationship would be found between the known escapements and subsequent numbers of returning sockeye salmon. If such a correlation could be established, management of the fishery would be easier and sockeye runs would be placed on a sustainable basis.

For many centuries Karluk's indigenous Alutiiq people had placed wooden and stone barriers across the river to impede and concentrate the migrating salmon for easy capture. The Russians also used similar barricades on Alaska's rivers in the 1800s to help them harvest salmon to provision their sea otter hunting crews. During his reconnaissance of Karluk Lake and River in 1889, Bean (1891) observed and photographed a line of boulders placed across the upper river to concentrate migrating salmon. Remnants of these early barriers continued to be visible at several locations on the Karluk River into at least the 1960s. Salmon counting weirs outwardly resemble some of these early river barriers, except that weirs have several narrow openings where fish are counted as they pass by and continue to the spawning grounds.

Ever since the first Karluk salmon counting weir was erected in 1921, federal, state, and private entities have continually discussed and reevaluated its location, design, and operation (Tables 3-1 and 3-2; Fig. 1-4). Changes to the weir since 1921 reflect the shifting balance between management, research, and conservation viewpoints. In this chapter, we review the history of the Karluk River weir and its continued importance as a research and management tool for sockeye salmon and other salmonid fishes.

Table 3-1
Karluk River weir operations, 1921–2010.

Year	Location	Agency	In charge	Date installed	Date removed	Operational problems[1]
1921	Lagoon	USBF	Fred R. Lucas	26-May	26-Oct.	1, 2, 4, 6, 7
1922	Lagoon	USBF	Fred R. Lucas	12-May	25-Oct.	1, 2, 4, 5, 6, 7
1923	Lagoon	USBF	Ray S. Wood	21-May	12-Oct.	2, 4, 5
1924	Lagoon	USBF	Ray S. Wood	14-May	21-Aug.	1
1925	Lagoon	USBF	Ray S. Wood	18-May	6-Oct.	2, 6
1926	Lagoon	USBF	Ray S. Wood	14-May	14-Oct.	2
1926	Portage	USBF	Harley W. Barton	2-June	11-Sept.	
1927	Lagoon	USBF	Ray S. Wood	12-May	13-Oct.	7
1928	Lagoon	USBF	Ray S. Wood	10-May	13-Oct.	2, 4, 6
1929	Lagoon	USBF	Ray S. Wood	10-May	14-Oct.	
1930	Lagoon	USBF	Ray S. Wood	17-May	9-Oct.	
1931	Lagoon	USBF	Ray S. Wood	14-May	8-Oct.	2, 6
1932	Lagoon	USBF	Harry D. Baer, H. Olafson	13-May	4-Oct.	1
1933	Lagoon	USBF	Charles P. Turner	14-May	9-Oct.	
1934	Lagoon	USBF	Morris Rafn	22-May	5-Oct.	1, 2
1935	Lagoon	USBF	Howard H. Hungerford	11-May	5-Oct.	2, 4
1936	Lagoon	USBF	James O'Brien	11-May	7-Oct.	1
1937	Lagoon	USBF	James O'Brien	17-May	6-Oct.	
1938	Lagoon	USBF	James O'Brien	13-Apr.	3-Sept.	1, 2
1939	Lagoon	USBF	James O'Brien	19-May	22-Sept.	2
1940	Lagoon	FWS	James O'Brien	19-May	25-Aug.	1
1941	Lagoon	FWS	Allan C. DeLacy	23-May	8-Sept.	
1942	Portage	FWS	Joseph Corkill	9-May	15-Oct.	2, 3
1943	Portage	FWS	Richard F. Shuman	31-May	9-Sept.	2, 3, 4
1944	Portage	FWS	Richard F. Shuman	25-May	31-Aug.	1, 2, 3
1945	Lake Outlet	FWS	Richard F. Shuman	29-May	10-Oct.	1
1946	Lake Outlet	FWS	Richard F. Shuman	3-June	20-Oct.	2, 4

Table 3-1 (cont.)
Karluk River weir operations, 1921–2010.

Year	Location	Agency	In charge	Date installed	Date removed	Operational problems[1]
1947	Lake Outlet	FWS	Richard F. Shuman	26-May	3-Oct.	
1948	Lake Outlet	FWS	Richard F. Shuman	20-May	3-Oct.	1
1949	Lake Outlet	FWS	Richard F. Shuman	22-May	28-Sept.	
1950	Lake Outlet	FWS	Philip R. Nelson	20-May	9-Oct.	
1951	Lake Outlet	FWS	Philip R. Nelson	27-May	13-Oct.	
1952	Lake Outlet	FWS	Philip R. Nelson	25-May	7-Oct.	
1953	Lake Outlet	FWS	Philip R. Nelson	18-May	2-Oct.	
1954	Lake Outlet	FWS	Philip R. Nelson	20-May	1-Oct.	
1955	Lake Outlet	FWS	Philip R. Nelson	13-May	4-Oct.	
1956	Lake Outlet	FWS	Philip R. Nelson	20-May	6-Oct.	
1957	Lake Outlet	BCF	John B. Owen	15-May	3-Oct.	
1958	Lake Outlet Tower	BCF	John B. Owen	31-May	1-Oct.	
1959	Lake Outlet Tower	BCF	John B. Owen	31-May	7-Oct.	
1960	Lake Outlet	BCF,ADFG	Robert F. Raleigh	29-May	10-Oct.	
1961	Lake Outlet	BCF,ADFG	Robert F. Raleigh	22-May	3-Oct.	
1962	Lake Outlet	BCF,ADFG	Richard Gard	14-May	29-Sept.	
1963	Lake Outlet	BCF,ADFG	Richard Gard	20-May	28-Oct.	
1964	Lake Outlet	BCF,ADFG	Richard Gard	17-May	17-Oct.	
1965	Lake Outlet	BCF,ADFG	Richard Gard	15-May	2-Oct.	
1966	Lake Outlet	BCF,ADFG	R. Gard, B. Drucker	18-May	22-Sept.	2
1967	Lake Outlet	ADFG		17-May	28-Sept.	
1968	Lake Outlet	ADFG		13-May	7-Oct.	
1969	Lake Outlet	ADFG		23-May	12-Oct.	2, 7
1970	Lake Outlet	ADFG		27-May	12-Oct.	
1971	Lake Outlet	ADFG	Thomas A. Emerson	13-June	12-Oct.	
1972	Lake Outlet	ADFG	Thomas A. Emerson	31-May	28-Sept.	
1973	Lake Outlet	ADFG	Greg Moore	8-June	10-Oct.	
1974	Lake Outlet	ADFG	Rod Neterer	31-May	10-Oct.	
1975	Lake Outlet	ADFG	Rod Neterer	3-June	2-Oct.	
1975	Lagoon Tower	ADFG	Robert Tomaselli			
1976	Lagoon	ADFG	Harry Dodge	23-May	17-Sept.	1, 2
1977	Lagoon	ADFG	Len Schwarz, Ken Langlois	21-May	8-Oct.	2
1978	Lagoon	ADFG	Herman Savikko	19-May	23-Oct.	1, 2
1979	Lagoon	ADFG	Mark Willette	13-May	5-Oct.	
1980	Lagoon	ADFG	Charles Burkey, Jr.	26-May	10-Sept.	1
1981	Lagoon	ADFG	Tim Perry	29-May	23-Sept.	
1982	Lagoon	ADFG	Steve Brown	20-May	15-Sept.	1
1983	Lagoon	ADFG		15-May	25-Sept.	
1984	Lagoon	ADFG	Matt Cole	22-May	29-Sept.	1
1985	Lagoon	ADFG		23-May	26-Sept.	
1986	Lagoon	ADFG		21-May	2-Oct.	
1987	Lagoon	ADFG		20-May	29-Sept.	
1988	Lagoon	ADFG		25-May	17-Sept.	
1989	Lagoon	ADFG		22-May	16-Sept.	
1990	Lagoon	ADFG		29-May	8-Sept.	
1991	Lagoon	ADFG		26-May	23-Sept.	
1992	Lagoon	ADFG	Ed Sampson III	25-May	26-Sept.	
1993	Lagoon	ADFG	Mike Brase	24-May	29-Sept.	
1994	Lagoon	ADFG		9-May	23-Sept.	
1995	Lagoon	ADFG	Michael Anderson	20-May	24-Sept.	
1996	Lagoon	ADFG	Michael Anderson	24-May	25-Sept.	1, 2
1997	Lagoon	ADFG		19-May	25-Sept.	
1998	Lagoon	ADFG		21-May	26-Sept.	2
1999	Lagoon	ADFG		26-May	23-Sept.	
2000	Lagoon	ADFG		25-May	24-Sept.	8
2001	Lagoon	ADFG		24-May	18-Sept.	
2002	Lagoon	ADFG		23-May	28-Sept.	
2003	Lagoon	ADFG		17-May	28-Sept.	2, 8
2004	Lagoon	ADFG		22-May	6-Oct.	1, 8
2005	Lagoon	ADFG		27-May	24-Sept.	2, 8
2006	Lagoon	ADFG		21-May	20-Sept.	
2007	Lagoon	ADFG		20-May	26-Sept.	
2008	Lagoon	ADFG		23-May	22-Sept.	2
2009	Lagoon	ADFG		23-May	29-Sept.	
2010	Lagoon	ADFG		23-May	19-Sept.	

[1] 1 = salmon carasses, 2 = high water, 3 = aquatic weeds, 4 = debris, 5 = high tide, 6 = muddy water, 7 = ice, 8 = bear damage to weir.

Table 3-2

Biological advantages and disadvantages of the three weir locations on the Karluk River.

Weir on the Lower Karluk River near Lagoon

Advantages

1) Sockeye salmon counts are more complete because they include those spawning in Karluk Lake, its tributary streams, and upper Karluk River. Small numbers of sockeye spawning below the weir in Karluk Lagoon must be added to the counts.
2) Sockeye salmon counts are obtained closer to the commercial fishery, allowing for better management decisions. Weir tenders can periodically survey Karluk Lagoon to estimate the numbers of salmon that have passed the commercial fishery, but have yet to pass the weir.
3) Sockeye scales collected close to the ocean are in better condition for reading ages.
4) Counts of other salmon species are more complete—pink (July–August), Chinook (May–July), coho (August–September), and chum.
5) Counts of up-migrating steelhead (September–October) and down-migrating kelts (May–June) are more complete.

Disadvantages

1) Pink salmon carcasses that drift downstream in even-numbered years often threaten to washout the weir in August–September.
2) Steelhead kelts must efficiently pass the weir in May–June or suffer increased mortality.

Weir at Karluk River Portage

Advantages

1) Sockeye salmon counts are more complete because they include those spawning in Karluk Lake and its tributary streams and in the upper Karluk River.
2) Pink salmon carcasses that drift downstream seldom threaten the weir.

Disadvantages

1) Masses of aquatic plants growing just upstream in the Karluk River drift against the weir in late summer, requiring regular cleaning to prevent its washout.
2) The weir is further removed from the commercial fishery, giving longer travel times for up-migrating sockeye and making management decisions more difficult.
3) Pink salmon counts are incomplete because much spawning occurs in the river downstream.
4) Steelhead kelts must efficiently pass the weir in May–June or suffer increased mortality.

Weir near Karluk Lake's Outlet

Advantages

1) Pink salmon carcasses and aquatic weeds seldom threaten the weir's integrity.

Disadvantages

1) The count of fall-run sockeye salmon is less complete because some fish spawn in the Karluk River below the weir and their numbers must be estimated.
2) The weir is further removed from the commercial fishery, giving longer travel times for up-migrating sockeye and making management decisions more difficult.
3) Sockeye salmon scales collected further from the ocean are more difficult to age.
4) Counts of pink, Chinook, coho, and chum salmon are incomplete because most of these fish spawn in the Karluk River below the weir.
5) Steelhead counts are incomplete because most winter in the Karluk River downstream from the weir. Kelt counts are incomplete.

Weir near Karluk Lagoon (1921–41)

1921

The USBF installed a wooden picket weir across the Karluk River in the summer of 1921 and counted the sockeye salmon migrating upstream. This, Alaska's first salmon-counting weir, was located on the lower Karluk River a short distance upstream of Karluk Lagoon and 5 km from the ocean at Karluk Spit. A total of $500 was appropriated for the weir and cabin, the weir lumber alone costing $400. The 93 m weir had three counting gates, one in mid river and one near each riverbank. Fred Lucas, USBF fish culturist at Afognak hatchery, installed and operated the Karluk weir in 1921, under the general supervision of Gilbert:

> [Speaking of the Karluk River weir, 1921] A site for the rack was decided upon just above the head of the lagoon. This spot was chosen principally because it was just out of reach of the tides, a comparatively smooth and level gravel bottom, as narrow a place as could be found within a mile and to facilitate the transportation of material as this had to be carried or dragged up the river proper by main strength and ackwardness.
>
> For the foundation of the rack, we used three legged "horses" . . . They were constructed of poles about ten inches in diameter, the two down stream legs seven feet long and the upstream leg nine feet long. These horses were spaced ten feet apart, then two stringers (also poles) were nailed on parallel with the water line. The pickets, (1½″ × 1½″ sawed lumber) were then nailed on at right angles to the stringers and spaced close enough so the fish could not get through.
>
> The material and tools necessary for building the barrier, left Kodiak on the gas boat "America", April 25th and picked up a tow of poles for the frame work at Whale Island near Afognak.
>
> Everything was discharged safely at the mouth of the Karluk River next day. The material was rafted and floated up the lagoon, then dragged up the river to the rack site. Living quarters were established in the old

hatchery, property of the Alaska Packers Association, about one half mile below.

The vents were constructed so they could readily be adjusted to any desired width enabling us to let the fish through only as fast as they could be easily tallied. A cloudy sky or muddy water will sometimes slow the work down, often preventing all the fish at the barrier getting through before dark. A piece of white canvas laid flat on the river bottom and arranged so the fish must swim over it, helps greatly.[2]

Weir operations and fish counting proceeded without unexpected major problems for most of 1921, and for the first time, accurate counts of adult sockeye reaching the spawning grounds were obtained. Without a doubt, the counting weir on the Karluk River proved to be feasible to operate and valuable for the data collected.

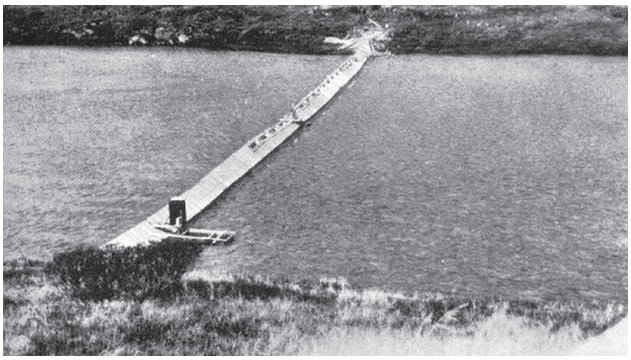
William Baumann, USBF warden at Afognak, operated the weir in the final weeks of the 1921 season (19 Sept.–3 Nov.) and described several weather-related problems with maintaining the weir into late October:

[Speaking of the Karluk River weir, late 1921] You will notice that no fish were tallied September the 30th and October the 6th. Those days were after the heavy rains which caused so much trouble by bringing down large quantities of debris, such as dead fish, turf grass and some small brush, which kept us cleaning rack all day. Anyway the river was too rily to see the fish. Just before these floods the fish would come to the rack in great numbers, most of the counting was done in the afternoon. Preparations were made October 27th to take up the barrier as the temperatures were falling rapidly. And October 28 started to take off pickets as drift ice was coming down, also anchor ice was forming. The water raised nearly to the top of rack and the rack had the appearance of a worm fence and some of the horses slipped back two or three feet owing to the heavy pressure. Ice had to be knocked off of pickets and horses before taking them to the river bank. Two horses were left in River, as Mr. Lucas and myself thought it would be a good idea. It might help determine the force of the ice.

November 2 packed up all paraphernalia and started for Karluk. Had to break ice along the shore of lagoon to get dories out as lagoon was frozen over about one third distance.[3]

[2] Lucas, Fred R. 1922. Report of the census of red salmon that escaped to the Karluk Lake spawning grounds during the season of 1921. U.S. Dep. Commer. Bur. Fish. Unpubl. report. 14 p. Located at NARA, Anchorage, AK.

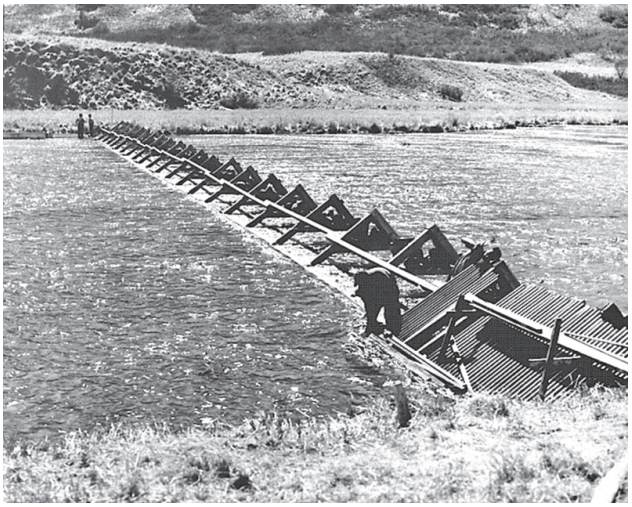
[3] Letter (10 November 1921) from W. E. Baumann, Afognak, AK, to Henry O'Malley, Seattle, WA. Located at NARA, Anchorage, AK.



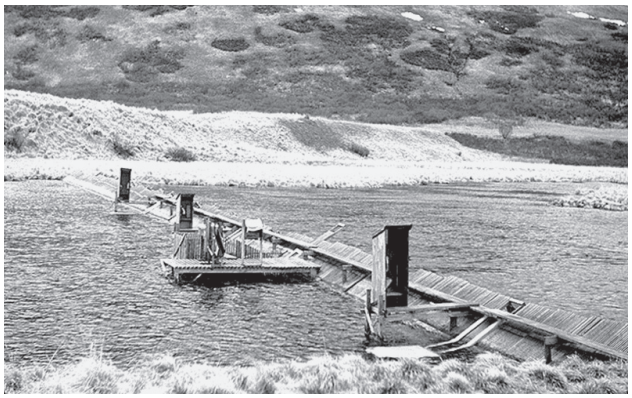
First Karluk River salmon counting weir, on lower river just upstream of Karluk Lagoon, 1921. (From Bower, 1922)

The materials and methods used to install, operate, and remove the Karluk River weir have remained nearly the same since 1921. Typically each year, the weir was installed in May and removed in September or October, all weir parts and lumber being stored on the riverbank for the winter because of the ice-covered river. The weir was usually constructed directly across the river at a right angle to the riverbanks and current, though an angled weir was tried during a few years.

To install the weir, large tripods (known as "horses") made of stout poles or timbers were placed in a straight line across the river, spaced about 3 m apart, and positioned with one tripod leg facing upstream and two legs facing downstream. Rocks from the river were placed on the tripods to add weight and stability to resist the river's force. Next, two rows of wooden stringers were nailed to the upstream legs of adjacent horses and parallel to the water surface, one stringer



Installing the Karluk River weir, near Karluk Lake's outlet, 18 May 1949. (Auke Bay Laboratory, Auke Bay, AK, FWS-1125)



Karluk River salmon counting weir, near Karluk Lake's outlet, 20 May 1954. (Clark S. Thompson, Shelton, WA)

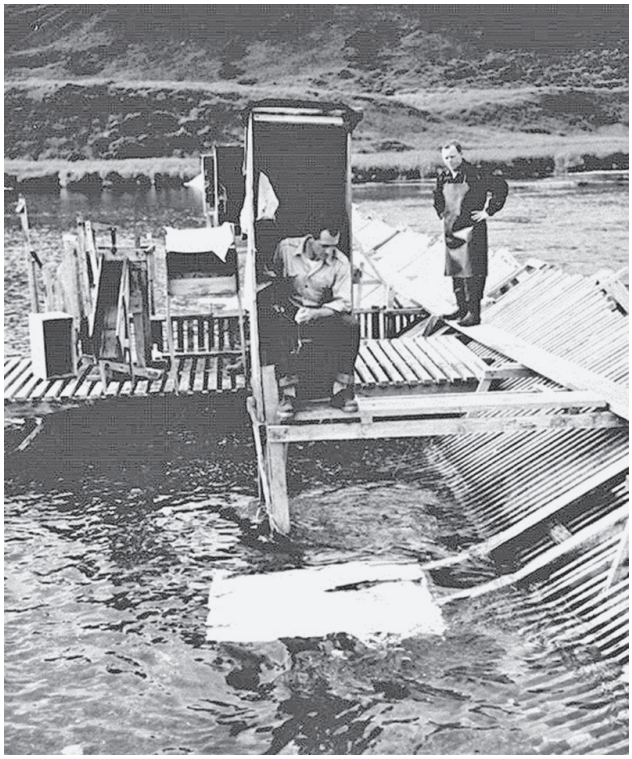
positioned near the water surface and the other located nearer the top of the horses.

Wooden pickets were then attached perpendicularly to the stringers, with one end against the river substrate and the opposite end near the top of the horses. Pickets were narrowly spaced to prevent fish passage but still allow the river to flow through the weir. Pickets were placed at the same inclined angle as the upstream leg of the horses, and by their continuous placement across the river they formed a barrier to upstream salmon movements, except at several counting gates. Wooden pickets (3.8 × 3.8 cm) were used for many years, each being nailed to the stringers, but in recent years, aluminum rods joined into panel units have been used.

Three or more counting gates were built into the continuous wall of pickets. With counting gates closed, the weir formed a complete barrier to upstream salmon migration. Depending on the number of salmon ascending the river, one or more gates were opened and the fish were counted through the weir. Workers had access along the entire weir by a horizontal catwalk plank, sometimes with safety handrails. Common features added to the basic weir were gates, traps, and pens for catching adult salmon; smolt traps; and various platforms to help workers collect scales and measure fish lengths and weights. Because the crew worked in all types of weather, including strong winds and heavy rains, small houses were sometimes built over the counting gates to give partial shelter. White cloth or panels placed on the river bottom just upstream of each counting gate gave a contrasting background to help identify and count passing fish.

Although biologists primarily installed the 1921 Karluk weir to count migrating adult sockeyes, they also learned much more about sockeye salmon biology, seasonal migrations of other fish species, and the river ecosystem. Diligent weir operation required several workers to devote constant daily attention to river conditions, weather, and fish movements from May to October. The daily duties of counting fish upstream, maintaining the weir, recording water temperatures, and living next to the river provided a sustained series of biological observations from one location. Such regular observations thus resulted, somewhat unexpectedly, in much greater knowledge about the river and its biota. In particular, the dynamic nature of its fish migrations became known for the first time, including the upstream and downstream migrations of adults and juveniles of all five salmon species, Dolly Varden, and steelhead trout. Further, the biologists observed the interactions between salmon and various birds (bald eagles, gulls, terns, and mergansers) and mammals (brown bears, river otters, and red foxes).

Typical of most new attempts at field research, operating the 1921 Karluk weir revealed unexpected biological features. Immediately after installing the barrier, many Dolly Varden began accumulating above the weir, becoming so numerous that they interfered with salmon counting. The weir barred the annual downmigration of Dolly Varden to the ocean each spring, these fish being very thin and in poor condition follow-



Counting sockeye salmon as they come through the Karluk River weir, September 1948. (E. P. Haddon, Auke Bay Laboratory, Auke Bay, AK, FWS-1223)

ing winter. Next, the weir crew observed the down-migration of sockeye smolts in early June, but poor collecting gear kept them from getting specimens for Gilbert to study. Spawned-out steelhead (kelts) also accumulated above the weir in June and the crew modified the weir to let them pass downstream. Dolly Varden began their up-migration from the ocean in July, and in stark contrast to the down-migrants, these fish were in excellent condition. As the season progressed, the up-migrations of Chinook, pink, and chum salmon were noted, followed by coho salmon and steelhead in the autumn. Regular samples of sockeye salmon scales were lacking in 1921, except for two incidental collections from 211 fish in August.

Once the counting weir began successful operation on the Karluk River in 1921, fishery biologists and managers immediately expanded its use beyond the primary purpose of counting sockeye salmon. The weir quickly became an important research and management tool, a value that continues to present times.

1922

Based on the 1921 operations, Lucas recommended that the 1922 weir be installed at an angle across the river, reasoning that this position would concentrate down-migrating Dolly Varden and steelhead kelts at the lower end, where they could be easily trapped or released. Up-migrating sockeye supposedly would concentrate at the upper end of the weir, where several counting gates would be located. Consequently, the 1922 weir was installed at a 50° angle across the river, with two counting gates at the upper end. Being angled, additional lumber was needed to construct the 110 m weir. Additional counting gates were later built into the weir near its middle and lower end. After operating the 1922 angled weir, Lucas concluded it had no advantages in speeding the up-migration of salmon.

The 1922 weir had several additional purposes besides counting sockeye salmon, perhaps the most important being the collection of adult sockeye scales from throughout the whole run. From more than 2,000 scales collected in 1922, Gilbert determined the age composition of the Karluk sockeye run. Because of their scientific value, salmon scales have been taken at the weir nearly every year since 1922. Another new function of the 1922 weir was to capture and destroy thousands of migrating Dolly Varden; these fishes were believed to be serious predators of sockeye eggs and juveniles. Destroying these charr was part of an ongoing predator control program by governmental agencies and commercial interests.

In contrast to the relatively trouble-free weir operations of 1921, more difficulties occurred with the 1922 weir because of the pink salmon run which, at Karluk, varies greatly in abundance between even- and odd-numbered years. Runs are usually small in odd years and large in even years. As the 1922 weir season began, Lucas and his weir crew realized that the pink salmon run might be larger than in 1921, but they were mainly concerned whether they could simultaneously distinguish and count both sockeye and pink salmon as they swam through the open gates. In fact, about 400,000 pink salmon entered the river from mid July to mid August 1922, and the crew found it impossible to accurately count the pink salmon on days of large migration.

Nevertheless, these counting errors were the least of their problems as pink salmon passed through the weir gates, spawned in the river upstream, and then died. By 10 August salmon carcasses began to drift downstream and accumulate against the weir. The crew made a valiant effort to clean the weir and keep it functional, spending many hours throwing carcasses over the weir. Rainstorms raised the river on 20 August, flushing masses of decomposing carcasses against the weir faster than they could be removed. An estimated 50,000 carcasses accumulated against the weir on 21 August, plugging it and causing the river to overtop and undermine the structure. To save the weir from complete washout and destruction, sections of pickets were removed to pass the carcasses downstream. But these open weir sections allowed uncounted sockeye salmon to move upstream from 20 August to 4 September, causing inaccuracies in the 1922 escapement data.

The 1922 season dramatically illustrated the main problem of operating a weir on the lower Karluk River—the risk of weir washout from masses of even-year pink salmon carcasses. From 1922 to present times, pink salmon carcasses have caused problems for weir crews. Tarleton Bean (1889), the first biologist to investigate Karluk's fisheries, commented on the pink salmon carcasses from the huge 1880 run:

> [At Karluk River, 1880] At the end of the run the humpbacks began dying, and those that did not get up to Karluk Lake were floating down dead or dying for one month. The banks of the stream were strewn with dead fish, and the stench was more easily imagined than endured.

Perhaps it was fortunate that the first Karluk River weir operated in an odd-numbered year when the new weir crew could focus on counting sockeye and not have to contend with pink salmon carcasses. One wonders if the weir program would have continued if the

first attempt had been in an even year when pink salmon carcasses destroyed the structure. In 1922 Lucas and his crew lived at the abandoned APA hatchery, located about 0.8 km downstream from the weir.

1923

Compared with the previous year's problems, the 1923 weir operation ran rather smoothly. Ray Wood, a USBF employee at the Afognak Fisheries Station, installed and operated the weir. Four counting gates were used to give salmon rapid upstream passage. He closely observed the migratory behavior of adult sockeye, finding that they first gathered for several days in a deep hole at the upper end of Karluk Lagoon and then proceeded upstream to the weir as a group. Salmon arrived at the weir in pulses, there being several days with few fish, followed by several days with many fish. He noted that adult salmon migrated at night and wondered if counting hours might be extended by installing lights on the weir. Wood observed the spring down-migration of sockeye smolts and measured the length of a few fish (100–200 mm). The spring down-migration of Dolly Varden seemed smaller than usual, but the up-migration was large, at times outnumbering the sockeye salmon. The crew installed weir traps to capture and destroy Dolly Varden, but failed to collect sockeye salmon scales in 1923.

An unusually high tide, in combination with strong winds and a storm-swollen river, overtopped and undermined the weir on 12 October, letting some sockeye pass upstream uncounted. Grass, aquatic weeds, and debris drifted against the weir and plugged it; the increased water pressure pushed the weir a few feet downstream and broke some pickets. Shortly thereafter conditions improved and the crew safely removed the structure, storing it on the riverbank for winter.

After operating the Karluk weir for three years and gaining critical fisheries data, there was no doubt of its value and that the program would continue. Nevertheless, following the 1923 weir season and continuing for the next four years, considerable discussion, controversy, and indecision occurred over its proper location on the Karluk River. These events apparently were triggered by a 1923 letter from A. K. Tichenor, APA Vice President and General Superintendent, to Henry O'Malley, Commissioner of Fisheries, criticizing the location of the lower Karluk River weir.[4] Tichenor declared that the weir harmfully impeded the salmon's ascent of the river. He argued that swift currents at the weir exhausted many salmon before they found open gates, causing them to give up their migration, drift downstream, and either die or spawn unnaturally in the lower river or Karluk Lagoon. As evidence, he alleged that carcasses of exhausted salmon often lined the riverbanks below the weir and that salmon disfigured from repeated attempts to pass the weir had been caught off Karluk Spit. Tichenor suggested that the weir be moved upstream to Karluk River Portage, reasoning that the deep slow current there would let salmon rest while waiting to pass the weir. He recommended a V-shaped weir built with netting or wire mesh and felt that the Portage site was superior because it had good access from Larsen Bay.

Tichenor's criticisms of the existing weir site apparently came from information he received in 1923 from Gordon Jones, then serving his first year as APA Superintendent at Larsen Bay cannery. Jones visited the Karluk River weir once on 10 June 1923 when sockeye were present, but no salmon carcasses then lined the banks. Since salmon carcasses only littered the lower river following the even-year pink salmon runs, it appears that Jones's knowledge of the weir came from his one visit, plus previous observations made by others who confused pink salmon carcasses with those of sockeyes. Assertions that the weir exhausted salmon and caused them to drift downstream to spawn in Karluk Lagoon also lacked credibility. Typically, only a few hundred or thousand sockeye spawned in Karluk Lagoon each year, perhaps a natural remnant of the millions of hatchery fry released during 1896–1916. As biologists now realize, salmon are not easily deterred from their spawning migration; they tenaciously pursue their natal spawning grounds.

Both Lucas and O'Malley responded to Tichenor's criticisms, discounting his claim that the weir harmed the sockeye salmon. Direct observations of the salmon's migratory behavior by Lucas and Wood during 1921–23 failed to support the criticisms. O'Malley cautioned Tichenor that moving the weir further upstream may reduce cannery harvests because escapement counts would not include salmon present in the river below the weir. Nevertheless, he accepted the possibility of moving the weir to the Portage, provided the canneries contributed to the costs. Tichenor offered APA's assistance in establishing a new weir, agreeing to transport weir materials from San Francisco to the head of Larsen Bay on company vessels. He also offered to supply a horse and sled to transport

[4] Letter (17 October 1923) from A. K. Tichenor, Vice-President and General Superintendent, APA, San Francisco, CA, to Henry O'Malley, U.S. Fish Commissioner, Washington, DC. Located at NARA, Anchorage, AK.

the materials from Larsen Bay to the Karluk River Portage and agreed that the 4 km trail needed improvements across marshy areas.

Once the possibility existed in late 1923 of moving the weir's location, lengthy discussions ensued within the USBF and canneries about its best site on the Karluk River. Three locations were advocated: 1) the present site on the lower river upstream of Karluk Lagoon, 2) the Portage, and 3) the upper river near Karluk Lake's outlet. Arguments for or against a particular site focused on research, management, and practical concerns (Table 3-2). These discussions continued over the next four years, often with proponents of particular sites changing their preferences.

The main problem at the lower weir site was the threat of washout every two years from pink salmon carcasses, this causing inaccurate sockeye salmon counts. At the Portage site, carcasses would be less of a problem, but Lucas warned of a possible difficulty with that location. Growing immediately upstream of the Portage were dense beds of aquatic plants that decayed each autumn and drifted downstream, again potentially plugging the weir and threatening its washout. Lucas considered Tichenor's suggestion of a web weir at the Portage impractical because of the aquatic plant problem and stated that a typical wooden weir was better at that site. If a web weir must be used, Lucas suggested a fourth site in upper Karluk Lagoon, the nets crossing on pilings from the old hatchery to just upstream of a deep hole on the north bank.

Some biologists and officials believed the best weir site was at Karluk Lake's outlet. Pink salmon carcasses and aquatic vegetation would seldom be problems there, but, unfortunately, weir counts would be inaccurate because many thousands of fall-run sockeyes spawned in the Karluk River below the proposed site. The abundance of these river spawners may not have been well known when the alternative weir sites were being considered. Inaccessibility, poor communications, and remoteness from the commercial fishery also made this a poor site for the fishery managers and canneries. Reconciling sockeye salmon escapements and commercial catches would be more difficult because of fish that had escaped the fishery and were ascending the river, but not yet counted at the weir. For practical reasons, Lucas believed a web weir could be successfully operated at Karluk Lake's outlet.

1924

As the 1924 weir season approached and debate continued over the proper location, it soon became evident for logistical reasons alone that no change could be made for the upcoming season. Gilbert and O'Malley decided to keep the 1924 weir on the lower Karluk River, but adjusted its location slightly to secure it against pink salmon carcasses. A 107 m angled weir with six counting gates was installed on the lower river in 1924. Although an angled weir in 1922 had failed to speed salmon migration, this design was used again in 1924 with the idea that it would help move pink salmon carcasses downstream by floating them along the weir face to an opening at the lower end.

Notable as these preparations were, they proved to be futile because over 4,000,000 pink salmon flooded into the Karluk River in 1924. To let the hordes of upmigrating pink salmon quickly pass the weir, all six counting gates were opened. Since complete counts of sockeye salmon were impossible with the two-man crew, they estimated the escapement by proportionally expanding the accurate counts made at one or two gates to the four or five open uncounted gates. At the manned gates, they accurately counted sockeye, but only estimated pink salmon. Lucas commented on the large numbers of salmon at the 1924 weir:

> [At Karluk River weir, 1924] The river was so full of fish behind the rack that there was danger of them smothering, or otherwise hurting themselves, if held until they could be counted through by the two men.[5]

This huge salmon run, combined with low flow conditions in mid summer, overwhelmed the oxygen capacity of the Karluk River and caused a large fish kill for 16 km above the weir. All fish species in the river were killed, including adult sockeye, pink, and Chinook salmon, Dolly Varden, steelhead, and juvenile salmonids:

> [At Karluk River weir, 1924] After they passed through the weir quite a number died before spawning for a distance of at least ten miles above the weir. The cause for this is not known for certain, but owing to the fact that salmon fingerlings, adult red salmon and trout in the area also died and floated down the stream it is believed that there were too many fish for the oxygen content of the water, especially as there seemed to be a slight fall of the water level at the same time.[6]

Many pink salmon carcasses, plus those from the fish kill, began accumulating against the weir and threatened to overwhelm it by 22 August. To save the

[5] Letter (30 December 1924) from Fred R. Lucas, Superintendent, Clackamas, OR, to Commissioner of Fisheries, Washington, DC. Located at NARA, Anchorage, AK.
[6] See footnote 5.

weir from complete washout, the crew removed many pickets and stopped counting sockeye salmon. They unsuccessfully tried to reestablish the weir and resume counting in late August and September, but pink salmon carcasses continued to be such a problem that the 1924 weir season ended two months earlier than normal and well before the sockeye run had ended.

Following passage of the federal White Act in 1924, the Karluk River weir became an important tool for management of its sockeye salmon runs. This law mandated that 50% of the total salmon run must be allowed to escape to the spawning grounds, a proportion assumed to be sufficient to sustain this resource. By matching ongoing counts from the weir with harvest data, managers could now accurately determine if the 50% mandate was being met and, if not, they could close the fishery.

1925

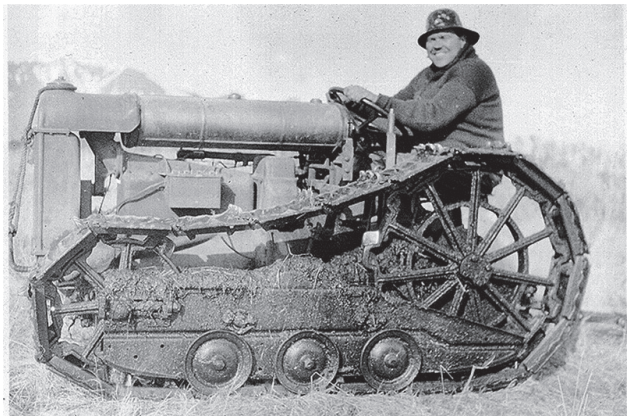
The 1925 weir was again installed on the lower Karluk River and operated without major problems. Gilbert visited the weir in May–June to collect sockeye smolts and scales from down-migrating Dolly Varden. The weir crew used three fish traps to capture and destroy Dolly Varden. They tested a fish wheel at the weir, but it was unsuccessful. They installed wire leads below each counting gate to guide and speed the upstream passage of adult sockeye, but these additions also proved unsuccessful. In late May, workers captured a "candlefish" (either *Ammodytes hexapterus* or *Thaleichthys pacificus*) at the weir, a rarity in the lower river.[7] Gilbert tagged 200 adult sockeye in early August and measured their travel time between Karluk Spit and the weir. Weir tenders saw sockeye salmon spawning in upper Karluk Lagoon and noted the presence of gill-net marked salmon. Heavy rains in early October raised the river, making counting difficult in the turbid waters.

By mid 1925 the USBF had decided to locate the 1926 weir near Karluk Lake's outlet to avoid the problem of salmon carcasses. After the 1924 ordeal, pink salmon carcasses were expected to be a problem in the lower river in 1926. To solve the problem of the lake's remoteness, O'Malley initially wanted a telephone line installed between Karluk Spit and Karluk Lake, but later he tried to procure wireless telephones.

APA vessels delivered a large load of lumber to the western end of Larsen Bay in 1925, near the ocean end of the Portage trail. This lumber was intended for a new weir and cabin or tent frame shelter at Karluk Lake in 1926. USBF warden Howard Hungerford was responsible for transporting the lumber, coal, and other supplies to the lake. To accomplish this task, a Fordson track-laying tractor was moved from Afognak Fisheries Station to Larsen Bay in late 1925.

The original plan called for hauling the materials to Karluk Lake with the tractor and sled during the winter of 1925–26, when a deep snow pack capable of supporting heavy loads normally covered the unstable muskeg. Hauling began in January 1926, but mild weather and lack of snow prevented direct hauling to Karluk Lake. By mid January Hungerford had moved the materials 1.2 km to the ridge above Larsen Bay by hauling small loads across temporarily frozen ground in early morning hours. Continuing this work, he hauled six tractor loads to the Karluk River Portage and then about 2 km upstream, where he unloaded it on the riverbank, still 12 km from Karluk Lake. This hauling occurred without the benefit of snow cover, the tractor pulling the loaded sled across rough frozen muskeg.

At this point the tractor broke down and repairs consumed the next two weeks. When hauling resumed in early February, the tractor badly mired in muskeg on its first trip across the Portage trail and required two days to extract. As the time remaining for winter snows and cold temperatures diminished, Hungerford realized he was unlikely to get the weir materials to the lake. Nevertheless, by mid February as the weather turned milder, he had hauled another four loads to the



USBF biologist Arnie J. Suomela driving Fordson tractor across the Karluk River portage trail, 1934. (Joseph Thomas Barnaby, from Lynn L. Gabriel, Herndon, VA)

[7] In 1903 Cloudsley L. Rutter reported that in the Karluk region "candlefish" were the sand launce, *Ammodytes alascanus,* now a synonym of *A. hexapterus.* Cloudsley L. Rutter memo notebook for 1903 (16 June–14 July), Karluk Spit, Portage, River, and Lake. Located in Box 130, Barton Warren Evermann papers, Library Special Collections, California Academy of Sciences, San Francisco, CA. Also see Chamberlain (1907).

supply cache on the riverbank. He made no further attempts to haul materials by tractor and sled, or to get weir materials to Karluk Lake, even though 8–10 additional loads remained on the ridge above Larsen Bay. Hungerford concluded that enough lumber existed at the Karluk River supply cache for a 122 m weir, which could be constructed at the Portage site in 1926. O'Malley still wanted the 1926 weir at the lake's outlet, but if that was impossible, to again install it on the lower river, not at the Portage. He suggested that Hungerford move the materials by skiff up the Karluk River in spring, but that was not done.

1926

Failure to transport the new weir materials to Karluk Lake's outlet in the winter of 1925–26 renewed the discussions of where it should be located, and a decision was urgently needed since the weir season rapidly approached. With 1924 in mind, biologists feared the 1926 pink salmon run would be so large that these fish might enter the spawning streams at Karluk Lake and damage eggs already deposited there by sockeye. Thus, one reason for choosing the lake weir site was to prevent pink salmon from entering the sockeye's spawning grounds. Though a wooden picket weir at the lake's outlet was impossible in 1926, O'Malley decided in mid April to place a weir on the lower Karluk River and a heavy web weir at the lake's outlet as a barrier to pink salmon. The cotton webbing could be procured and installed at the lake's outlet prior to the early August pink salmon run but not in time to count the June sockeye run.

These 1926 weir arrangements were unsatisfactory to Gilbert, who wanted two weirs in place to insure accurate counts of sockeye escapements, even if pink salmon carcasses rendered the lower weir inoperable late in the season. Also, two weirs would let him measure the travel times of sockeye migrating between Karluk Spit and Karluk Lake.[8] Finally, Gilbert, Hungerford, and Rich conferred at Larsen Bay on 25 May and decided that their only real alternative for a second weir in 1926 would be at the Portage site. Consequently, two Karluk River weirs operated in 1926, one on the lower river and another at the Portage. In 1926, the weir crews lodged in the abandoned hatchery at the lower river and in a new cabin at the Portage.

Rich spent considerable time in early 1926 at the lower Karluk River weir marking sockeye smolts and watching adults ascend the river, especially noting their behavior at finding and passing through the counting gates. Aware of past criticisms by the canneries, he decided their arguments against the weir had little merit:

> [At Karluk River weir, 1–2 June 1926] It was obvious that the weir formed no serious obstacle to the ascent of the fish as they easily found the openings.
>
> It is certainly an imposing sight to see them coming on up stream in large shoals, splashing over the shallow riffles in almost solid masses. They are especially numerous just below the rack where they are, nightly, slightly delayed. It is very evident, however, that the delay occasioned by the rack is by no means serious. The fish run lively for a time and then drop back in more quiet water below—possibly into the lag[oon]—and then come on up again later. There is no evidence that the fish are in any way injured by the delay. They lie quietly behind the rack, working along until they come to an opening through which they can pass. It has been claimed that the rack works a real injury to the run but now I can observe the conditions as they are here today and really believe that there is nothing to such a claim.[9]

Unexpectedly, over 2,500,000 sockeye salmon escaped to the Karluk River in 1926. The Portage weir had hardly been installed in early June when large numbers of sockeye accumulated downstream. Fearing the fish might smother, the crew opened all weir gates and removed sections of pickets on 10–11 June, allowing free upstream passage to about 350,000 sockeye. Operating two weirs in 1926 allowed the travel times of adult sockeye to be measured over the 20 km separating the two sites. Of 100 fish tagged at the lower weir on 19 July, they passed the Portage weir on 21–28 July.

Contrary to all expectations, the 1926 pink salmon run was small and salmon carcasses never threatened to wash out either weir. Pink salmon never reached the lake spawning grounds or damaged sockeye redds. When the large pink salmon run failed to appear by mid September, counting operations were ended at the Portage weir. The webbing material purchased to exclude pink salmon from the lake went unused.

As the 1926 weir season drew to a close, discussions began anew about the proper weir location for 1927.[10] The consensus weir site in September 1926 was Karluk Lake's outlet. Gilbert requested that O'Malley make an early decision so materials could be

[8] Letter (24 May 1926) from J. R. Russell, Field Superintendent, USBF, Seattle, WA, to Henry O'Malley, USBF, Washington, DC. Located at NARA, Anchorage, AK.

[9] Rich, Willis H. 1926 notebook. Location of original notebook unknown; copies at NARA, Anchorage, AK, and ABL Library, Auke Bay, AK.

[10] Discussions were between Henry O'Malley, Charles H. Gilbert, and several USBF personnel (Willis Rich, Howard Hungerford, Dennis Winn, and J. R. Russell).

transported well before the next weir season.[11] Yet, when Hungerford reported on the 1926 weir operations in October, he recommended that the best weir location was the lower river, not the Portage or lake's outlet:

> [Concerning the 1927 Karluk River weir location] It is recommended that this weir be maintained at its present location during coming years to secure an early and accurate count of salmon entering Karluk river. The prejudice under which this weir has labored is entirely a thing of the past and everyone interested in the conservation of salmon is convinced that its location is the logical one.[12]

Nevertheless, in December 1926, Hungerford, Gilbert, and Rich agreed that the 1927 weir should be located at the Portage, but they also wanted additional weir lumber transported and stored at the lake's outlet. This would give them the option of locating future weirs at any of three sites.[13] In February 1927 O'Malley and Dennis Winn preferred the site on the lower river, but sought further opinions from Gilbert and Rich. Gilbert agreed that the lower site had advantages for management purposes, there being fewer uncounted fish in the river, but in March Rich continued to prefer the Portage site. Finally, O'Malley decided that the 1927 weir would be on the lower river. This decision settled the question of the proper weir location for the next 15 years, without further discussions by USBF personnel or criticisms from the canneries.

1927

Although the 1927 location had been decided, when it came time to install the weir, some confusion arose about its design. A V-shaped weir with its apex pointing downstream had been planned to help Rich collect, mark, and census sockeye smolts. But the person installing the weir was unaware of the new design and he, instead, built a normal straight weir. A late breakup of the river ice delayed weir installation several weeks in 1927; the river banks and upper lagoon had large ice packs on 1 May. Once operating, the 1927 weir season proceeded without major problems.[14] Weir removal in late October proved to be difficult because anchor ice plugged the weir and caused a partial washout. Living quarters in 1927 were found in a room of the old hatchery building and in a woodshed. A small weir cabin was built in the summer of 1927 using lumber salvaged from the abandoned APA hatchery.

Rich continued to believe the best weir site was the lake's outlet and wanted to convince O'Malley and Gilbert to make the move in 1928. As Rich marked sockeye smolts at the lower weir in 1927, drifting algae and debris clogged his wire mesh traps, confounding efforts to capture and count these migrants. He believed smolt traps could be operated at the lake's outlet, plus it appeared to be a good location to capture Dolly Varden and count adult sockeye. Further, 1928 seemed to be a good time for moving the weir because existing materials at the lower river were worn and needed replacing. To lessen the difficulty of transporting lumber to the new site, Rich had planned on building the weir horses from cottonwood logs cut at the lake. He hoped to get a final decision on the 1928 weir from O'Malley and Gilbert so materials could be moved to the lake in the summer of 1927.

1928–41

Notwithstanding Rich's desire for a new weir site in 1928, it continued to be operated on the lower Karluk River during 1928–41. By 1927 the original weir lumber from 1921 was deteriorating and new living quarters were needed for the crew. The old hatchery building, once used by the weir crew for shelter, was completely gone by 1929, its lumber and parts having been scavenged for other uses. Thus, the USBF delivered new weir lumber to Karluk in 1929 for use in 1930. A small cabin was built at the weir in 1929 and another in 1932; the APA listed the two cabins in a 1933 inventory of their Karluk properties, though they charged the USBF no rent.

During this period, weir operation became a routine annual USBF duty. The weir was typically installed in mid May and removed in early October. Weir crews counted sockeye salmon and collected salmon scales

[11] Letter (27 September 1926) from Charles H. Gilbert, USBF, Stanford University, CA, to Henry O'Malley, Commissioner of Fisheries, Washington, DC. Located at NARA, Anchorage, AK.

[12] 1) Hungerford, Howard H. 1926. Report of operations at Karluk Weir (Lower) season of 1926. U.S. Dep. Commer. Bur. Fish. Unpubl. report. 4 p.
2) Hungerford, Howard H. 1926. Report of operations at Upper Karluk Weir, season of 1926. U.S. Dep. Commer. Bur.Fish. Unpubl. report. 5 p. Both located at NARA, Anchorage, AK.

[13] Letter (3 December 1926) from Howard H. Hungerford, Warden, Alaska Service, USBF, Seattle, WA, to Dennis Winn, Agent, USBF, Seattle, WA. Located at NARA, Anchorage, AK.

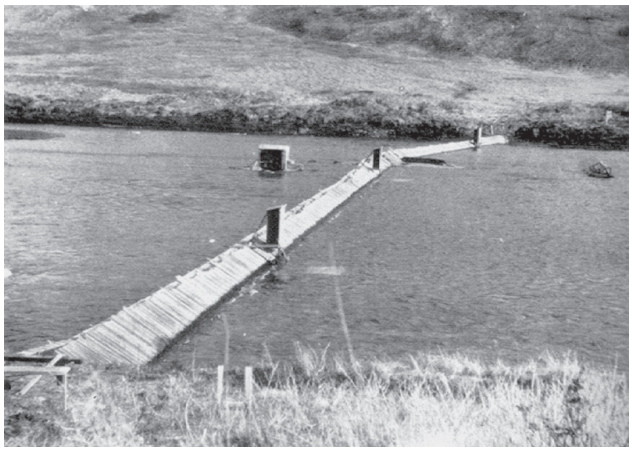
[14] A second weir was temporarily operated at Karluk River Portage in April–June 1927 by the USBF to capture downmigrating steelhead, these being artificially spawned and their eggs incubated in hatchery troughs placed in a nearby creek. This temporary Portage weir for taking steelhead eggs operated each spring during 1927–32 and 1953–59 (Table 3-3).

Table 3-3
List of temporary weirs on the Karluk River, 1927–64.

Year	Agency	Location	Type	Purpose	Operational dates
1927	USBF	Portage	Straight picket weir	Steelhead egg take	April–May
1928	USBF	Portage	Straight picket weir	Steelhead egg take	April–May
1929	USBF	Portage	Straight picket weir	Steelhead egg take	April–May
1930	USBF	Portage	Straight picket weir	Steelhead egg take	April–May
1931	USBF	Portage	Straight picket weir	Steelhead egg take	April–May
1932	USBF	Portage	Straight picket weir	Steelhead egg take	April–May
1941	FWS	Portage	Angled half weir	Dolly Varden capture	May
1953	ADF	Portage	V-shaped picket weir	Steelhead egg take	April–May
1954	ADF	Portage	V-shaped picket weir	Steelhead egg take	29 April–27 May
1955	ADF	Portage	V-shaped picket weir	Steelhead egg take	30 April–24 May
1955	FRI	Lagoon	Tower	Count sockeye salmon	
1955	FRI	Portage	Tower	Count sockeye salmon	
1956	ADF	Portage	V-shaped picket weir	Steelhead egg take	13-30 May
1957	ADFG	Portage	V-shaped picket weir	Steelhead egg take	4-24 May
1958	ADFG	Portage	V-shaped picket weir	Steelhead egg take	20 April–7 May
1959	ADFG	Portage	V-shaped picket weir	Steelhead egg take	28 April–6 May
1963	BCF	Portage	Straight picket weir	Sockeye travel time and river-spawner estimate	1 Aug.–30 Sept.
1964	BCF	Silver Salmon Cr.	Straight picket weir	Count, tag sockeye	August

and length-weight-sex data. The weir was a useful site to capture and sample the salmon.

Besides these primary tasks, fishery biologists conducted several studies at the weir, perhaps the most important being the smolt marking by Rich and Barnaby. They annually marked and released 50,000 sockeye smolts during 1928–36 to determine their ocean survival. Since smolts temporarily accumulated above the weir during their spring down-migration, this was a convenient capture site. Other studies included the abundance of gill-net marked salmon in 1930 and Dolly Varden migrations during 1937–41. Again, the Karluk weir was well-situated for observing, tagging, and recapturing these fish. The weir was also used to trap and destroy Dolly Varden, and this work filled the crew's spare time.



Karluk River salmon counting weir, lower Karluk River, 1930. (From Bower, 1941)

The financial turmoil of the Depression era was a very difficult period for the USBF at Karluk because of limited and uncertain funding for fisheries programs. Commissioner of Fisheries Frank Bell fired many permanent fisheries employees and most temporary workers in 1933, including some at the Karluk weir. He also closed the Afognak hatchery on 30 June 1933. The financial uncertainty continued for several years, and at times the Karluk weir program appeared close to ending, but funds were eventually reinstated. Wage costs at the Karluk weir were $2,486 in 1934 and $2,606 in 1936. Tight funding in 1936 caused Bureau warden Charles Turner to recommend that "if the allotment cannot be increased by at least $2,000, I suggest the weir program be curtailed."[15] Such drastic action never occurred and the Karluk weir program somehow managed to continue operating through these lean financial years.

Although installation and operation of the Karluk River weir followed a similar pattern each year during 1928–41, a few unusual occurrences occurred:

1) High water and ice altered the river channel in the winter of 1929–30. This required the 1930 weir to be moved 15 m downstream from its normal 1921–29 location. Since a straight weir could not be built from bank to bank because of the newly eroded channel, the 1930

[15] Turner, Charles. 1936. Report of operations, Kodiak, Afognak Dist., 1936. U.S. Dep. Commer. Bur. Fish. Unpubl. report. Located at ABL Library Files, Auke Bay, AK.

weir had two sections, one running straight across to a small island and another running at an angle upstream to the opposite bank.

2) For unknown reasons in 1938, weir installation occurred much earlier than normal (early April) as ice left the swollen river.

3) Carl Hubbs, an ichthyologist at the University of Michigan, visited the Karluk River weir on 4 August 1939 while investigating Bureau operations in Alaska.

4) Although weir tending was relatively safe, the Bureau's weir foreman James O'Brien fell from the weir and ruptured his left kidney on 21 August 1939. An APA doctor at Larsen Bay first treated him and he later recovered in Seward, Alaska.

5) In 1941 a weir tender intentionally inflated the pink salmon counts by about 100,000. He had heard about the large pink salmon run of 1940 and altered the 1941 counts to match the previous year. Supposedly, he counted 17,000 pink salmon per day before being replaced (5 August), but only 229 per day were counted after his departure. Few pink salmon carcasses littered the river in 1941, and less than 40 carcasses per day drifted against the weir.[16]

6) To aid their charr studies, DeLacy and Morton installed a temporary weir at the Portage in May 1941 using lumber stored at the site during the 1920s–1930s (Table 3-3). This weir angled upstream from the east bank and extended about half-way across the Karluk River. They designed the weir to concentrate and capture down-migrating Dolly Varden for tagging and measurement, but they were urgently called away to install the salmon counting weir on the lower river.

Pink salmon carcasses continued to be a maintenance problem for weir crews in the even years during 1928–40. Carcasses accumulated against the weir in August–September, greatly increasing the crew's workload. Large pink salmon runs occurred at Karluk in 1922, 1924, 1932, 1934, 1936, 1938, and 1940. When carcasses first arrived in late August or early September, the crew cleaned the weir by pewing each carcass to the downstream side. For example, they tossed 25,000 carcasses over the weir on one day in early September 1932. As the season progressed, however, pewing became difficult because decaying carcasses fell off the pew. Additional temporary workers were often hired to help clean the weir and sometimes day and night shifts were needed:

Dolly Varden temporary angled weir, Karluk River Portage, May 1941. (Allan C. DeLacy, from Catherine J. DeLacy, Seattle, WA)

> [Concerning the Karluk River weir, 1934] Mr. Morris Rafn who was in charge of the weir in 1934 worked so hard and dilligently at all hours of the day and night in a vain endeavor to keep the weir in operation that he seriously impaired his health and has been in a sanitarium ever since returning from duty in Alaska.[17]

Whenever rainfall increased the river flows in August–September, carcasses often arrived at the weir faster than they could be removed and this forced the crew to remove picket sections to flush decaying salmon downstream. Failure to open the weir risked its complete washout and destruction. Of course whenever the weir was open, sockeye proceeded upriver without being counted, impairing escapement accuracy. Thus, pink salmon carcasses continued to be the major oper-

[16] Memo (9 November 1942) from Allan C. DeLacy, Assistant Aquatic Biologist. Located at NARA, Anchorage, AK.

[17] Memo (23 January 1935) from J. T. Barnaby, Scientific Assistant, Seattle, WA, to Commissioner of Fisheries. Located at NARA, Anchorage, AK.

ational problem at the lower weir site and the main argument for moving it to another location.

When Barnaby led the sockeye research program at Karluk during 1930–38, he spent much time at the weir and knew of its problems. He often helped the crew clear carcasses from the weir and estimated escapements whenever they opened the weir. Barnaby realized that carcass removal greatly increased the crew's workload. Consequently, following the salmon carcass problems and hospitalization of one worker in 1934, he recommended moving the weir to the Portage.[18]

After similar problems in 1938, Barnaby and DeLacy repeated the recommendation.[19] They believed that the upstream weir site would solve the carcass problem since most pink salmon spawned in the river below the Portage. Since a steelhead weir had successfully operated at that site each spring during 1927–32, a counting weir also seemed feasible (Table 3-3). Additionally, a cabin for the weir crew already existed and a tractor trail provided good access from Larsen Bay. The lower weir site often had poor access when storms in Shelikof Strait prevented vessels from landing at Karluk Spit. During those times, the only access to the lower river required a long trip, first to Larsen Bay, then a hike across the Portage trail, and finally a 20 km float trip down the Karluk River. Since accurate pink salmon counts could not be made at the Portage, they suggested operating two weirs in even years—the lower weir until 20 August and then the Portage weir from 20 August to season's end. This two-weir idea was never tried.

Weir at Karluk River Portage (1942–44)

Following Barnaby and DeLacy's 1939 recommendation and the weir washout from pink salmon carcasses in 1940, the FWS[20] finally decided in 1941 to locate the 1942 weir at the Portage. Obviously, the recurring carcass problem created inaccuracies in the sockeye salmon counts in even years and needed to be resolved. The Portage site seemed to be a good solution.

During the initial debate in the 1920s over the proper weir location, Bureau employee Lucas warned that large masses of aquatic plants grew in the Karluk River upstream of the Portage. Since these plants died and drifted downstream every autumn, maintenance of the Portage weir would require regular removal of plant debris or risk its plugging and washout:

> [Concerning the Karluk River weir at the Portage] I would not recommend that it be constructed at Larsen's Bay Portage on account of the vegetation that would be coming against it and lack of material nearby. During the latter part of the season, the river for several miles above the portage trail is almost a solid mass of water plants which would be coming down against the weir. This grass is noticeable even at the present site, thirty miles farther down.[21]

The FWS likely knew in 1941 of this potential plant problem but considered it trivial. In a brief attempt to assess the seriousness of the problem, DeLacy checked the river at the Portage in May 1941, but he saw few drifting plants. The brief operation of the steelhead weirs each spring during 1927–32 also provided no data about river conditions in the autumn. Yet, the Portage weir had operated in August and early September 1926, apparently without problems from drifting plants.

Even with Lucas's warning about aquatic plants, plans proceeded for the 1942 Portage weir. Lumber for the new weir was delivered to Larsen Bay in August 1941, transported by boat to the head of the bay, and hauled by tractor to the Portage:

> [Concerning preparations for the 1942 Karluk River Portage weir, 1 August 1941] Al & I helped Geo. Skarbo unload weir lumber from *Eider*. Talked to Ferrandini . . . That was a prize *coup de etat* of Al's to get Ralph to dump off the new Karluk [weir lumber] here at Larsen Bay. That should make history up here. After breakfast we spent AM towing a pot scow alongside dock & loading the 60–4 × 6's, 24–2 × 4's & bundles of 1 × 4's. Then after lunch we hooked on to it with both *Gorb*[*uscha*] & *Tscha*[*wystcha*] [2 dories] in tandem & hauled it to Bens [west end of Larsen Bay]—1 to 2:10—& we made a place to pile it & got dinner & unloaded scow at high tide & then came home 1½ hrs to come back bucking tide & wind.[22]

Thus, the Portage weir was installed and operated from May to October 1942. Since the river channel was narrow at the Portage, the new weir's length measured about 30 m less than at the old site and required only 15 horses to cross the river. Weir operations proceeded

[18] See footnote 17.

[19] Memo (28 November 1939) from Allan C. DeLacy, Junior Aquatic Biologist, and Joseph T. Barnaby, Associate Aquatic Biologist, Seattle, WA, to Acting Commissioner, USBF, Washington, DC. Located at NARA, Anchorage, AK.

[20] In 1939 the Bureau of Fisheries was moved from the U.S. Department of Commerce to the U.S. Department of Interior and in 1940 it merged with the former Biological Survey to form the U.S. Fish and Wildlife Service (FWS).

[21] Lucas, Fred R. 1924. Report of the red salmon census at Karluk Alaska during the season of 1923. U.S. Dep. Commer. Bur. Fish. Unpubl. report. 4 p. Located at NARA, Anchorage, AK.

[22] Morton, William M. 1941 notebook. Located in personal papers of Robert S. Morton, Portland, OR.

without major problems from May to August 1942, but then aquatic plants began drifting downstream. Charles Petry, FWS fishery management agent, stated in his annual report that the weir was briefly out of commission twice from high water, but the real problem was drifting aquatic plants in September:

> [At the Karluk River weir, 1942] The weir foreman, Mr. Joseph Corkill, reports that the Karluk weir was temporarily out of operation during the first four days of September as the result of a cloud-burst. Overnight the river level rose so rapidly that large masses of aquatic plants, chiefly *Ranunculus*, were uprooted and drifted against the weir, producing a dam across the entire river. A short section of the weir washed out and additional pickets had to be removed in order to liberate the impounded water. By September 4 the river had receded sufficiently to permit the necessary repair work to be done, and normal operation was resumed on that day. Relatively few fish were running at the time of the accident, and an estimate will be made of the number that passed upstream while the weir was open.[23]

The weir again went out of operation the last week of September 1942, with the weir tender exclaiming "99 ton of weeds!"[24]

Richard Shuman operated the Portage weir in 1943 and once more fought the aquatic weed battle. Although it was his first field season at Karluk, by mid July he had searched the upper river for a new weir and research laboratory site, his efforts not being motivated by the 1942 weir problems. Instead, there was renewed research interest in the freshwater life of sockeye salmon, and a weir and laboratory near the lake would benefit future studies. Specifically, Shuman looked for a permanent weir site, envisioning a concrete structure designed to count down-migrating sockeye smolts and up-migrating adults. The area just below the lake's outlet fulfilled his requirements for these facilities:

> [Concerning the upper Karluk River, 18 July 1943] Examined area around outlet of lake with view to weir (permanent) in future. About 50 yards below lake seems to be an excellent spot. Bottom composed of medium and large rubble—with a blue clay conglomerate beneath. Excellent bottom for concrete work. No question of weir not being tight. Banks on both sides composed of glacial deposits of gravel and boulders, and should make quite good buttresses for weir or dam, and are sufficiently high. . . . The only thing against this as a weir site would be the heavy waves which come down the lake with strong south winds. A concrete or rock-crib breakwater might be necessary between the open lake and the weir screens.[25]

Shuman found a good building site for the research laboratory on the west riverbank of the lake's outlet and suggested a road route between Larsen Bay and Karluk Lake. The idea for a two-way weir originated from his previous work at Little Port Walter, Alaska, where a similar structure had been built in 1939. During seven field seasons (1943–49), he pursued the idea of a permanent counting weir on the Karluk River.

Events at the 1943 Portage weir soon reinforced Shuman's desire for a new weir site. The weir functioned well until mid August, but then aquatic plants began drifting downstream and the crew repeatedly cleaned these away for the next two weeks. When river flows increased in early September and greater masses of plants arrived at the weir, the cleaning efforts were completely overwhelmed. Soon, the crew removed the weir pickets and ended the salmon counts:

> [Karluk River weir, 2 September 1943] Weeds! Spent entire day cleaning weeds from weir. River up about 12″ this morning—a greater raise would have swamped us entirely.
>
> [5 September 1943] Busy with weir—counting and cleaning. Weeds coming down constantly. We can keep up, however, but a large raise in water level will swamp us. Weeds all up river rotting and ready to let go.
>
> [9 September 1943] Looks like we are in for it. Not many weeds today, but it has rained all day . . .
>
> [10 September 1943] The "worst" arrived! A light rain here all night, but apparently the storm still on at the lake—and yesterday's rain arrived (via the river) in early morning. River up 18 inches. Quite a few weeds on the weir by morning, and by 9:00 AM—Weeds. They came down in great floating patches, plugging the weir faster than we could get rid of them. By 10:00 AM it became necessary to remove gates and pickets from several sections to let the weeds through—and a spot to roll the already-accumulated weeds through. Balls of weeds weighing up to 400–500 pounds thus rolled through. Yet even so we could nowhere nearly keep pace. By late afternoon it was necessary to remove more pickets (otherwise the whole weir might carry away). In many places the water has undermined the pickets, and two horses have settled out of line.—Also had to remove section of pickets near west bank to protect the

[23] 1) Petry, Charles. 1942. Annual report of operations in the Kodiak District, 1942. U.S. Dep. Interior, FWS. Unpubl. report. 56 p. Located at ABL Library Files, Auke Bay, AK. 2) USBF. 1938–43. Monthly report of activities, 1938–43. U.S. Fisheries Biological Station, FWS Biological Station, and Section of Alaska Fishery Investigations, Seattle, WA. Unpubl. reports (September 1942). Located at NARA, Anchorage, AK.

[24] FWS 1942–46 notebook. Located at NARA, Anchorage, AK.

[25] Shuman, Richard F. 1943 notebook. Located at NARA, Anchorage, AK.

anchor there (some cutting took place during the day). . . . It is quite apparent that a weir cannot be maintained at this place for a late fall count. Only with a large crew of men (8–12)—and floodlights for night work—would make this at all possible. Even then the battle would be in doubt!!! The weir must be placed above this weed crop, if a fall count is to be attained.[26]

Shuman and his crew continued their heroic efforts for the next week, but huge masses of aquatic plants drifted against the weir. Even with many pickets removed to relieve the water pressure, the structure neared complete destruction. After surveying the river upstream, Shuman finally removed the weir on 20 September, ending the 1943 season several weeks early:

[At Karluk River weir, 18 September 1943] In AM took skiff and outboard and went up river about two miles to look at weed situation. Probably less than 20% have come down. All are rotting and occasionally one gives way. A real bunch of weeds due at next rain. Next wind will bring them, too, for both shores are lined with loose weed, and a wind will blow them loose. Hate to make the move, but can see no hope of replacing weir or keeping it in if we could replace it.[27]

After the problems of 1942–43, the FWS decided to move the weir upriver to Karluk Lake's outlet, though logistically it was impossible to get the lumber and supplies to the new site prior to the 1944 field season. At the time, the Karluk research program lacked the labor-saving benefits of air transportation. Instead, all weir materials had to be hauled across the Portage by tractor and sled, and then boated 14 km upriver to the new site. The FWS Scientific Division purchased a new Cletrac AG caterpillar tractor for the Karluk fisheries program in 1939 and this gave workers reliable transportation across the Portage trail.[28] In 1944 the Karluk field crew (four men) spent most of the summer hauling lumber and supplies from Larsen Bay to Karluk Lake's outlet, reportedly making 25 round trips (36 km each) before completing the arduous task.[29] Moving the materials upriver was particularly grueling, requiring them to physically pull and push heavily loaded boats 14 km against swift currents. Nevertheless, by summer's end the necessary lumber and supplies were ready for the 1945 weir season.

Operations at the 1944 Portage weir proceeded as in 1943, with aquatic plants causing major problems in the autumn. Further, 500,000 pink salmon passed through the weir and most of these spawned and died in the river between the Portage and lake. Pink salmon carcasses added to the aquatic plants floating downstream and forced removal of the weir on 1 September 1944, well before the sockeye runs ended. Thus, after trying to operate a weir at the Portage for three years, the FWS declared it to be a poor site:

[At Karluk River Portage weir, 1944] By late August aquatic plants in quiet section of river above weir began drifting against weir, mixed with thousands of dead spawned-out pinks. From August 27 to August 31

FWS Cletrac tractor and sled, Karluk, 1944. (Jerrold M. Olson, Auke Bay, AK)

Karluk River salmon counting weir at the Portage, 1944. (Jerrold M. Olson, Auke Bay, AK)

[26] See footnote 25.
[27] See footnote 25.
[28] Shuman made an unsuccessful attempt in May 1944 to drive the Cletrac tractor from the Portage trail to Karluk Lake.
[29] The 1944 crew included Richard F. Shuman, Don C. Yates, Jerrold M. Olson, and George D. "Dad" Shuman.

crew was split into day and night crews to keep river detritus from weir. This became impossible and on September 1 the weir was removed. This location obviously unfit for weir site.[30]

Weir near Karluk Lake Outlet (1945–75)

1945–57

A new wooden picket weir was built on the upper Karluk River in 1945, about 200–300 m below the lake's outlet. After installing the weir, Shuman and his three-man team erected a small weir cabin. The weir operated from mid May to early October without major troubles, confirming Shuman's decision to move the weir. Pink salmon carcasses and aquatic plants were no longer problems. The new location also was advantageous because the FWS research program then, and for the next 25 years, focused on the freshwater life of sockeye salmon at Karluk Lake. Here, the weir crew participated in the studies at the lake, while all the previous crews had been far removed from these activities. This new weir site on the upper river continued without major changes from 1945 to 1957.[31] Though the new location had obvious advantages, three new problems arose: 1) its inaccessibility, 2) matching commercial catches and weir counts, and 3) accounting for sockeye salmon spawning in the upper river below the weir.

In 1945, access to Karluk Lake meant a tedious journey of 18 km from Larsen Bay by tractor, hiking, and small skiff. Supplies only reached the lake with considerable physical effort. To remedy the isolation, in 1945–46 the FWS considered the idea of building a road between Larsen Bay and Karluk Lake, but before this proposal was implemented, access and supply to the lake became relatively simple in 1947 because of frequent flights by several FWS aircraft, especially by Grumman Goose NC–709 and NC–710. Thereafter, the need for an access road was seldom mentioned.

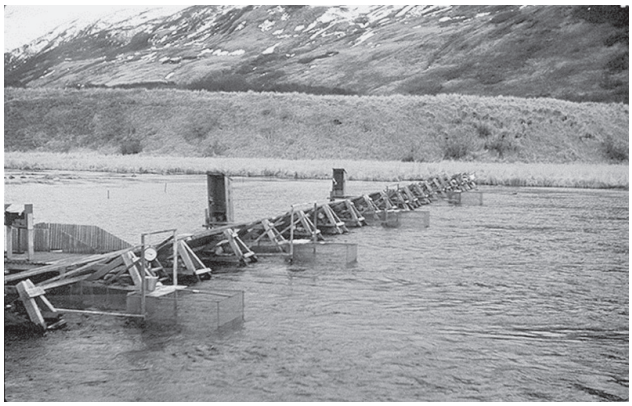
Though aircraft were increasingly common around Kodiak Island in the 1930s and early 1940s, they were not

[30] FWS. 1944. Karluk weir, 1944 (Portage Trail Site). Unpubl. report. 1 p. Located at NARA, Anchorage, AK.

[31] Three FWS fishery biologists directed the weir operations during this period: Richard F. Shuman (1945–49), Philip R. Nelson (1950–56), and John B. Owen (1957). In addition to the sockeye counting weir near the lake, a second weir temporarily operated each spring at the Portage during 1953–59. Each year in April-May, a V-shaped weir captured steelhead for artificial spawning, the eggs being shipped to Devil's Creek hatchery on Kodiak Naval Base for incubation. The temporary weir was removed prior to the spring-run sockeye migrations (Table 3-3).

North end of Karluk Lake and salmon counting weir located in upper river near lake's outlet, May 1957. (Auke Bay Laboratory, Auke Bay, AK)

Karluk River salmon counting weir and cabin near Karluk Lake's outlet, ca. 1952. (Charles E. Walker, Sechelt, BC)



Karluk River salmon counting weir, with four smolt traps built into the weir, 1955. (Clark S. Thompson, Shelton, WA)

used then by the USBF and FWS to assist fishery biologists because of difficult economic times and World War II restrictions on air travel. After the war ended, the use of nonmilitary aircraft greatly increased around Kodiak Island, and this mode of travel completely changed the old methods of transporting and supplying biologists at Karluk Lake. These aircraft greatly benefited Karluk's biologists by freeing them from the many mundane logistical tasks and expanding their research possibilities. Likewise, biologists stationed at Karluk Lake also benefited from more reliable radios that kept them in contact with other areas of Kodiak Island.

A second problem of the new weir site was the unknown relation between the commercial catches and weir counts of sockeye salmon. Because it took a number of days for adult sockeye to migrate 40 km from the ocean to Karluk Lake, an unknown lag time existed between catch and escapement. Shuman and Nelson partially solved this problem in 1945–46 by measuring the travel times of sockeye, tagging them in the lower river and then recording when they reached the lake weir.

A final problem of the new weir was its location within the river spawning area of fall-run sockeye. Thousands of sockeye spawned in the 200–300 m river reach between the weir and lake and for 2–4 km downstream. Since this weir location failed to count the fish that spawned downstream, it was necessary to estimate that group. Furthermore, some biologists claimed that the weir hindered the free upstream-downstream movements of adult and juvenile sockeye in the upper river (Thompson, 1950; Van Cleve and Bevan, 1973). As adult salmon home to a specific spawning site they often overshoot it, but later return to the exact location. The biologists reasoned that once river-spawning salmon passed through the weir, it formed a barrier to later downstream movement. Likewise, they felt that newly emerged fry that migrated upstream to the lake had difficulty passing through the weir.

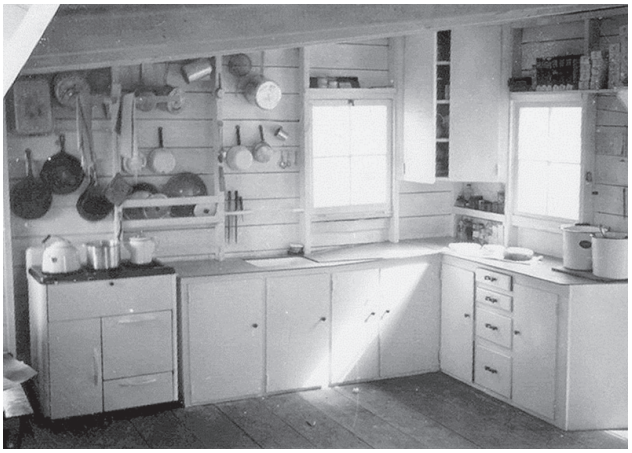
Over the next 20 years, all of these hindrance issues were addressed and found to be inconsequential.[32] Direct observations showed that adult sockeye, whether moving upstream or downstream, easily found open weir gates and passed through the weir. In fact, daily weir counts occasionally were negative when more fall-run adults moved downstream than upstream. For sockeye fry, most of the first upstream wave of these young fish had already migrated from the river to the lake before the weir was installed each spring. Typically, later fry migrated upstream along the west river bank, where they easily bypassed the weir through a section of large-meshed wire netting placed to block the adults. For the fry that migrated along the east river bank, the weir was modified with baffles to slow the current and aid their passage.

Pink salmon carcasses rarely were problems at the new weir site, but sockeye carcasses regularly drifted

FWS Grumman Goose NC709, Karluk Lake, 1950. (E. P. Haddon, FWS National Digital Library, FWS-1300)

FWS Grumman Goose N709, Karluk Lake, 1954. (Clark S. Thompson, Shelton, WA)

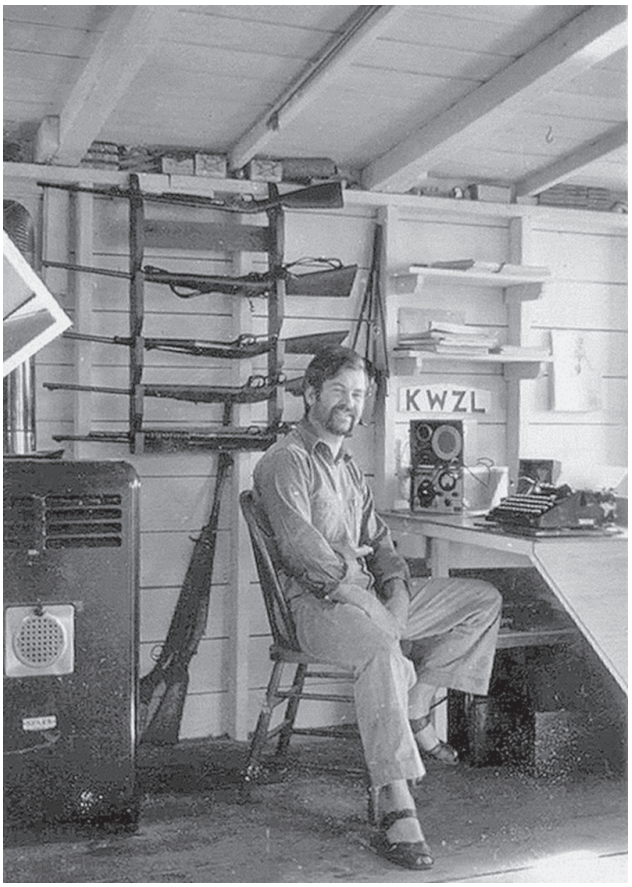
[32] BCF biologists Richard Gard, Benson Drucker, and Charles DiCostanzo, with more than 15 years of combined experience in operating the Karluk River weir near the lake's outlet, felt that the weir had minimal effects on migrating sockeye salmon adults and fry.
1) Letter (2 June 1972) from Charles J. DiCostanzo, Deputy Laboratory Director, ABL, Auke Bay, AK, to Richard Van Cleve, College of Fisheries, FRI, University of Washington, Seattle. Located in ABL files, Auke Bay, AK.
2) Letter (5 July 1972) from Ben Drucker, Technical Advisory Division, NMFS, Washington, DC, to Reuben Lasker, NMFS. Copy in the personal papers of Richard Gard, Juneau, AK.
3) Letter (10 February 2005) from Richard Gard, Juneau, AK, to Richard L. Bottorff, South Lake Tahoe, CA.



Interior of Karluk River weir cabin, near Karluk Lake's outlet, 1945. (Jerrold M. Olson, Auke Bay, AK)

Karluk River weir cabin, pantry, and bunks, 1945. (Jerrold M. Olson, Auke Bay, AK)

against the weir each autumn. These seldom threatened the weir's integrity, but they added to the crew's maintenance chores. For example, in 1945 about 30,000 sockeye spawned in the river above the weir and many carcasses accumulated on the weir face. Similarly in late 1948, several hundred or thousand sockeye and pink salmon carcasses were removed daily. Strong south winds blowing down Karluk Lake occasionally carried debris into the upper river where it collected on the weir and required removal.



Jerrold Olson, Karluk River weir cabin, 1945. (Jerrold M. Olson, Auke Bay, AK)

Though the counting weir successfully operated near the lake's outlet in 1945, Shuman was not satisfied—he wanted a permanent two-way weir on the upper Karluk River. Accurate measurements of up-migrating adult sockeye and down-migrating smolts were valuable data for the fisheries program. The river just below the lake's outlet suited his plans for a concrete weir.[33] Shuman formally proposed the idea to FWS officials in 1946–47 and estimated the costs at $20,000 for the two-way weir, plus additional expenses for a house and laboratory, a road from Larsen Bay, and auxiliary weirs on several Karluk Lake tributaries.

Response to his idea must have been favorable since engineers surveyed the proposed site in late July 1948, producing detailed topographic maps. To determine the strength of river forces and ice action that would press against a permanent weir, Shuman had wooden posts driven into the river's substrate in November 1948 and left them over the winter.[34] A full set of engineering drawings showing all construction details of the two-way weir, including a fish ladder on the east bank, were completed in May 1949.[35]

Shuman attempted to build the permanent weir on the upper Karluk River during the 1949 field season using FWS resources, his assistant Philip Nelson, five

[33] See footnote 25 (18 July).

[34] Freeman, Arthur. 1948 notebook (3 November). Original notebook in personal papers of Arthur Freeman, Indianapolis, IN.

[35] The two-way weir project was known as FWS Construction Job No. 5213.

summer employees,[36] about ten laborers, and support from the U.S. Navy's base at Kodiak. Arriving at Kodiak in May, Shuman arranged with the Navy to use an LCT for transporting lumber and construction supplies to Larsen Bay, a tug for transporting equipment to Larsen Bay, and a TD9 bulldozer for excavating weir foundations. Despite these plans, the Navy bulldozer was useless because it could not be driven to Karluk Lake. On the first attempt, it immediately mired in the soft muskeg after leaving the Portage tractor trail, far from the lake. Extracting the bulldozer and returning it to Larsen Bay required several days.

Undaunted, Shuman decided to drive the lighter FWS Cletrac caterpillar tractor from Larsen Bay to Karluk Lake. This proved to be a difficult two-day ordeal over unstable ground, through thick brush, and across a temporary bridge at Silver Salmon Creek, but the tractor and sled eventually reached Karluk Lake. FWS Grumman Goose 709 and a Norseman airplane hauled 150 tons of lumber, construction materials, and equipment from Larsen Bay to Karluk Lake in mid June. The tractor and sled hauled the supplies from the lakeshore downriver a short distance to the project site, slightly below the 1949 picket weir.

Shuman began excavating the weir foundations in mid June using the tractor and a slip scraper, a combination that worked well, but slowly. He built a small cofferdam to isolate the excavation from the river and installed pumps to remove seepage water. Excavations continued for five days, but the pumps failed to remove inflowing water fast enough and the sides kept slumping back into the hole. Finally in late June, Shuman ended the work:

> [At upper Karluk River just below lake's outlet, 29 June 1949] Dug all AM. Going fairly well until within 24" of bottom. Water impossible to keep out. Jaeger pump very poor—keeps losing prime. Gravel pouring in at sides. Bulkhead will not keep it out. At 4:00 PM gave up. Will go to Kodiak and report complete failure. First job that has completely stopped me.[37]

No further attempts were made to build a permanent two-way weir at Karluk, though Shuman continued until at least 1951 to recommend an accurate measurement of the smolt migration.[38]

[36] FWS summer employees at Karluk in 1949 were Raymond N. Breuser, James Kindler, Charles J. Hunter, John S. Crawford, and George D. Shuman.

[37] Shuman, Richard F. 1949 notebook. Located at NARA, Anchorage, AK.

[38] Shuman, Richard F. 1951. Trends in abundance of Karluk River red salmon with a discussion of ecological factors. Manuscript prepared for *Fishery Bulletin* 71, vol. 52. Unpubl. 56 p. Located at ABL, Auke Bay, AK.

Coffer dam for construction of a two-way permanent salmon counting weir, upper Karluk River, June 1949. (Richard F. Shuman, Auke Bay Laboratory, Auke Bay, AK)

Excavating footing for a two-way weir, upper Karluk River, June 1949. (Richard F. Shuman, Auke Bay Laboratory, Auke Bay, AK)

The wooden picket weir continued to be operated each year during 1945–57 near the lake's outlet, and fairly accurate counts of sockeye salmon were obtained.[39] Nevertheless, the weir had a serious unsolved problem—it was located within the spawning area of fall-run sockeye and possibly obstructed their homing movements. In 1950 William Thompson expressed the belief that "every weir, which hinders the process of trial and error by to and fro or up and down migration, is preventing the homing of individuals to their own best environment, one which may vary widely within

[39] In 1951 new weir lumber was purchased in Seattle, shipped to Zachar Bay on the vessel *Dennis Winn,* and flown to Karluk Lake.

Using a slip scraper and Cletrac tractor to excavate the footing for a two-way weir, upper Karluk River, June 1949. (Richard F. Shuman, Auke Bay Laboratory, Auke Bay, AK)

the same stream." His colleagues at the University of Washington and the Fisheries Research Institute—Donald Bevan, Charles Walker, and Richard Van Cleve—shared similar views

1958–59 Counting Tower

One alternative to a wooden picket weir was a counting tower, an elevated platform positioned on the riverbank with good views across the river. The main advantage of this method was that no physical structure was placed in the river to impede the free movements of adult and juvenile salmon. As salmon migrated past the tower, an observer counted them. In actual practice, rather than constantly manning the tower throughout the day, counting usually occurred for part of each hour and then was proportionally extended for the remaining time. While counting towers appeared to be an elegant simple solution to the problems of picket weirs, in practice, they had some serious drawbacks.

Bevan and Walker, likely at Thompson's direction, explored the Karluk River from lake to lagoon for counting tower sites in 1955. They operated a counting tower at Karluk Lagoon for five weeks, but it proved unsatisfactory.[40] Another site below the Portage was inadequate because surface reflections seriously reduced their visibility.[41] After these preliminary attempts in 1955, Bevan and Walker spent less time at Karluk and devoted no further effort to the counting tower idea. Van Cleve visited the Karluk River weir in 1957 and recommended that it be discontinued, especially during the midseason sockeye salmon run.[42]

Concern that Karluk's wooden picket weir harmed sockeye salmon convinced FWS biologists to try a counting tower in 1958–59. They erected a 6.4 m tower on the east bank of the upper river in 1958, just below the lake's outlet.[43] Observers counted salmon for 10 minutes each hour and then extrapolated the count for the remainder of the hour. Almost immediately, problems arose with the counting tower, the most serious being count accuracy. Counting began at 1:00 A.M. and continued until 11:00 P.M. during the long daylight hours of mid-summer, only stopping for two hours of darkness. At the time, it was unknown if salmon migrated at night; if they did, the counts were inaccurate. As the hours of darkness increased from August to October, this potential counting error increased. To answer the question of night migration, biologists attempted to measure it by using various types and arrangements of artificial lights shining on the river, but this gear often failed or created reflections that made it difficult to see the salmon. Even with adequate lighting, night counts remained inaccurate because distinguishing the different salmon species was often impossible, though Dolly Varden could be distinguished from salmon. Biologists never completely solved the problem of night migration, the best estimate being that it was about 20–30% of day migration.

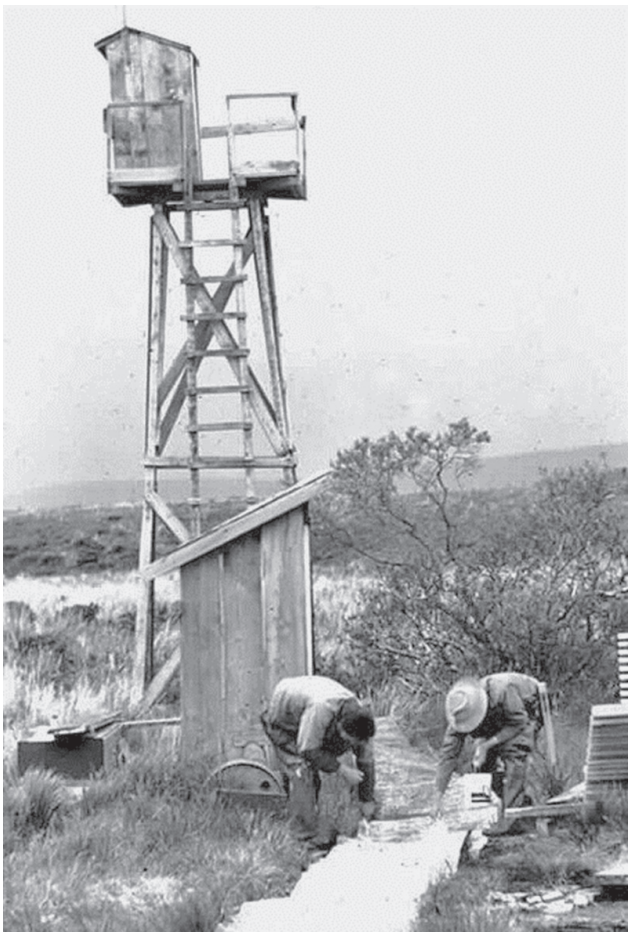
Further problems existed in identifying salmon from the counting tower. Because the Karluk River was 60–90 m wide at the tower, observers found it difficult to see and count salmon on the far side of the river. To

[40] Bevan, Donald E. ca. 1957. Research activities from 1948 to 1957 inclusive. Kodiak Island Research Fund, FRI, University of Washington, Seattle, WA. Unpubl. report. 2 p. Located in Donald E. Bevan papers, Manuscripts and University Archives Division, University of Washington Libraries, Seattle.

[41] Memo (16 April 1958) from Philip R. Nelson, Fishery Research Biologist, Annapolis, MD, to W. F. Royce, Assistant Regional Director in Charge of Research. Located at NARA, Anchorage, AK.

[42] Owen, John B. 1957 notebook (18 July). Original notebook from the personal papers of John B. Owen, Grand Forks, ND; to be donated to NARA, Anchorage, AK.

[43] BCF. ca. 1958. Fish counts at Karluk Lake. Unpubl. report. 13 p. Located at NARA, Anchorage, AK.

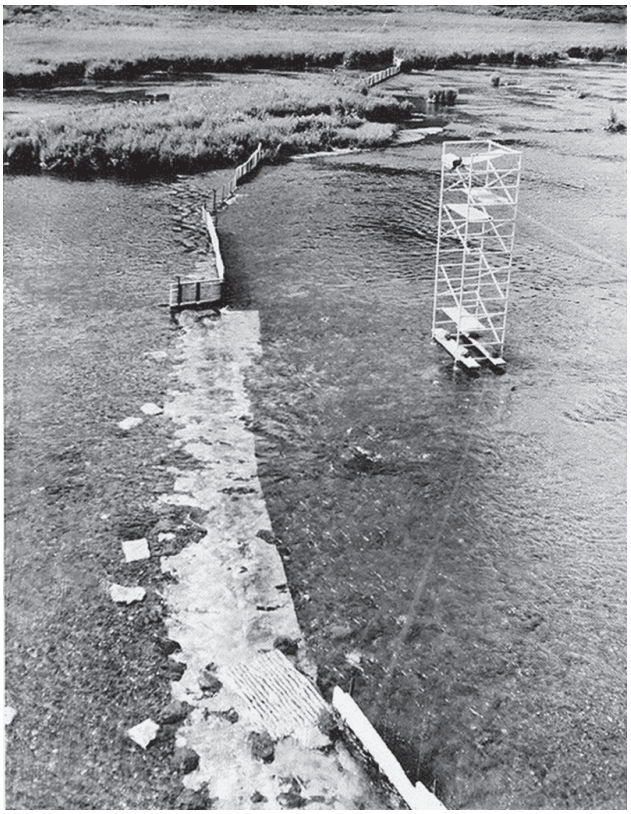


Counting tower used to enumerate adult sockeye salmon, upper Karluk River, June 1958. (Auke Bay Laboratory, Auke Bay, AK)

remedy this, they installed a fence across part of the river, leading the salmon toward a 20 m wide opening nearer the tower. To further improve visibility, they placed white panels (2.1 m wide) on the river bottom to increase contrast between the salmon and substrate. These changes improved the counting effort, but altered the salmon's migratory behavior. First, just as the previous wooden picket weir had done, the installed fence hindered the downstream movements of salmon. Second, the white river panels made salmon reluctant to continue upstream. They gathered just downstream of the panels until a sufficiently large school had accumulated, and then rapidly crossed the white strip in a flowing mass. The white panels needed constant cleaning since passing fish covered them with gravel.

Additional problems occurred when large numbers of sockeyes passed the tower faster than they could be counted. Surface reflections occasionally obscured the salmon, though polarizing sunglasses helped visibility. When river-spawning sockeyes were present each autumn, fish moved both upstream and downstream past the tower and this required that counts be tallied in both directions to determine the net migration. Counting was further complicated in autumn since both unspawned and spawned-out sockeyes moved downstream past the weir; counts of only the former were subtracted from the upstream migration. Therefore, observers had to tally salmon numbers moving in different directions and also instantly recognize species and spawning condition from a long distance—this supposedly simple task was overwhelming.

If the above difficulties were not enough, further problems arose while trying to collect scales and run composition data from sockeye salmon. To do this, biologists built a trap to collect salmon just upstream from the tower, but most fish avoided the trap. When workers tended the trap, salmon altered their normal upstream migrations past the tower. To capture enough salmon, they were forced to use seines in the river, but these were thought to be biased samples. Finally in frustration, the biologists installed a wooden picket weir downstream from the tower in July 1958 to efficiently collect scales and run composition data.



Light tower, guide fences, and white substrate section to help count adult sockeye salmon, upper Karluk River, 1958. (John B. Owen, Auke Bay Laboratory, Auke Bay, AK)

Despite the frustrations and uncertainties of 1958, biologists again used a counting tower at Karluk in 1959. Since the previous tower had blown down during the winter, they erected a new tower in the spring. Operation of the 1959 tower proceeded similarly to that experienced in 1958. Biologists continued experimenting with ways to improve the counts and solve problems, but uncertainties and frustrations remained. Consequently, following the 1959 field season when the FWS reviewed the effectiveness of the 1958–59 counting towers, few positive arguments were given for continuing with this method.[44] Because of the various fences and traps placed in the river, the overall open area for free migration was rather limited, possibly making it more difficult for adult sockeyes to move downstream than with the previous picket weir.

A particularly sharp criticism of the counting tower was the uncertainty it introduced into the sockeye salmon counts, the vital data needed by fisheries managers and researchers. Night migration and species identification problems remained unsolved. Questions also continued about the accuracy of extrapolating 10-minute counts to the whole hour. No evidence existed that the counting tower significantly benefited the sockeye fry that migrated upstream along the riverbanks. Finally, the counting tower required additional labor to operate and this diverted time and effort away from ongoing research programs. Therefore, the FWS abandoned the Karluk River counting tower after the 1959 field season and it was not tried again for many years.

1960–66 BCF–ADFG Transition of Responsibilities

Installation and operation of the Karluk River weir was the sole responsibility of several federal agencies from 1921 to 1959, including the USBF (1921–39), FWS (1940–55), and BCF (1956–59). The State of Alaska assumed full responsibility for managing Alaska's fisheries on 1 January 1960, but because the BCF had an ongoing research program and facilities at Karluk, they continued to support the weir for a number of years. Therefore, the wooden picket weir was installed and operated at Karluk Lake's outlet under the joint responsibilities of the ADFG and BCF during 1960–66, a period of transition when both agencies contributed to its costs and labor. Initially, the BCF installed and maintained the weir since the data collected were vital to their sockeye research, and this effort continued through 1969. The ADFG assigned one person to help at the weir during 1960–63; they contracted weir installation and operation to the BCF and provided funding for 1964–66.

The rationale for the Karluk River weir and its operations slowly changed after 1960, though this did not become obvious until the 1970s. When ADFG assumed their management responsibilities in 1960, these included the state's commercial, sport, and subsistence fisheries. Though the primary purpose of the Karluk River weir was to collect data on the commercially important sockeye salmon, over the years much biological information had been obtained about other salmonid fishes. Biologists studying these other fish species recognized the weir's value and suggested modifications to aid their research. Richard Marriott, ADFG sport fish biologist, suggested in 1967 that a counting tower or weir be operated on the lower Karluk River to gather data on fall-run coho salmon and steelhead. Implementation of his idea was years away, but it showed the growing interest in using the weir for other purposes than to count sockeyes. Significantly, Marriott's recommendation called attention to the impracticality of the existing weir site at the lake's outlet when studying Karluk's other fish species.

In addition to the main Karluk River weir, several secondary weirs briefly operated on the upper river for specific studies in the 1960s. Gard (1973) operated a second weir at the Portage from early August to late September 1963 (Table 3-3). He tagged adult sockeyes at the Portage and measured their travel time over the 14 km to the main weir. Further, using mark-and-recapture techniques, he estimated that the number of fall-run sockeyes that spawned in the Karluk River below the main weir was 10% of the total escapement (Gard and Drucker, 1965). This correction was then applied to subsequent weir counts. Another temporary weir was operated on the Karluk River near Silver Salmon Creek in late 1964, about 5 km downstream from Karluk Lake, again to estimate fall-run river spawners.

Although not directly related to the Karluk River weir, in 1964 while investigating the Terror Lake hydroelectric project on northeast Kodiak Island, the U.S. Bureau of Reclamation briefly evaluated a similar plan for Karluk. The Larsen Bay hydroelectric project included plans for a dam near the Karluk River portage that raised Karluk Lake by 4.6 m and a penstock (3 m diameter) feeding a 30,000 KW power plant on Larsen

[44] BCF. ca. 1959. Justification for replacement of Karluk Tower operation with weir. Unpubl. report. 6 p. Located at NARA, Anchorage, AK.

Bay. Apparently, once the significant impacts on Karluk's fish and wildlife were emphasized by BCF Regional Director Harry L. Rietze and ADFG Commissioner Walter Kirkness, no further efforts were made to pursue this project.[45]

1967–75 ADFG Weir Operation near Karluk Lake Outlet

The ADFG assumed full responsibility for operating the Karluk River weir in 1967, partly because of changing federal and state budgets. Since BCF funding was then limited, it was difficult for them to continue with both the sockeye research and weir operations at Karluk. In contrast, ADFG then received additional funding for fisheries programs after passage of the federal Anadromous Fish Act in 1967. Consequently, following the 1966 field season, the BCF requested that ADFG take over weir operations, collection of run-composition data of adult sockeye, and enumeration of sockeye smolts:

> [Concerning the Karluk River weir, 1967] Due to budgetary limitations and the resignation of Richard Gard from the Karluk Lake project, it is requested that the Alaska Department of Fish and Game assume responsibilities for the Karluk River weir, sampling of the adult red salmon escapement, estimate of smolt migration and sampling of red salmon smolts. With the loss of the project supervisor and without foreseeable replacement due to current BCF limitations, the State could more efficiently take over the above mentioned activities.
>
> With funds now available to the State, and with cuts in BCF funding at the present project level resulting in limitation to research, it is certainly more feasible to the mutual benefit of both the Bureau of Commercial Fisheries and the Alaska Department of Fish and Game to have the latter organization take over adult counting and smolt enumeration at Karluk Lake. Since Statehood, counting of the red salmon escapement into the Bristol Bay area has been taken over by the Alaska Department of Fish and Game. In the last several years, they have assumed the duty of smolt enumeration in the Kvichak, Naknek and other systems in the Bristol Bay area. Under the new Anadromous Fish Act, enumeration of adults and smolts at Karluk Lake by the State would be a natural extension of their province.[46]

In actual practice, the BCF installed the Karluk River weir during 1967–69, analyzed the sockeye salmon scales, and conducted the smolt studies, while the ADFG operated the weir and collected the run composition data on adult sockeyes. These mutual operations continued until the BCF ended its research program on Karluk's sockeye in 1969.

The ADFG continued to operate the Karluk River weir near the lake's outlet during 1967–75. They improved the weir in 1972–73 by replacing the wooden pickets with 2.5 cm aluminum pipes. These smooth pipes allowed sockeye smolts to easily pass through the weir and decreased maintenance since less debris caught on the weir. Even so, the ADFG encountered some problems during those nine years. In 1967, 1968, and 1972 unspawned, fall-run sockeyes unexpectedly died (perhaps from warm lake temperatures) and drifted against the weir (Blackett et al., 1969).[47] Heavy rains in late May and early June 1969 washed out the weir until 11 July. The same year a crew member shot a brown bear trying to enter the weir cabin.[48] In 1972 picket sections were removed for two days to let 20,000 adult sockeyes move downstream to spawn in the river below the weir.[49]

The ADFG decided in 1972 that the existing weir site at Karluk Lake's outlet was unsuitable because of the uncounted sockeyes that spawned in the upper river each fall. Total sockeye escapement was a combination of the fish counted through the weir and an estimate of the river spawners below the weir (about 10% of total escapement). Beyond these counting inaccuracies, the ADFG thought that the existing weir might hinder the homing behavior of river spawners. This view was also held by Van Cleve and Bevan (1973), who believed that the upper river was the most important

[45] 1) Letter (22 April 1964) from U.S. Bureau of Reclamation, Alaska District Headquarters, Juneau, AK, to Harry L. Rietze, Regional Director, USFWS, BCF, Juneau, AK. Located at NARA, Anchorage, AK.
2) Letter (16 April 1965) from Harry L. Rietze, Regional Director, USFWS, Juneau, AK, to George N. Pierce, District Manager, U.S. Bureau of Reclamation, Alaska District Headquarters, Juneau, AK. Located at NARA, Anchorage, AK.
3) Letter (25 May 1965) from Walter Kirkness, Commissioner, ADFG, to Harry Rietze, Regional Director, USFWS, BCF, Juneau, AK. Located at ASA, Juneau, AK.

[46] Memo (20 October 1966) from Benson Drucker, Acting Project Leader, Karluk Lake, Red Salmon Investigations, BCF, Auke Bay, AK, to Laboratory Director, BCF, Auke Bay, AK. Located at NARA, Anchorage, AK.

[47] Lechner, Jack, Martin F. Eaton, Kenneth R. Manthey, Louis A. Gwartney, and Lawrence M. Malloy. 1972. Kodiak area management annual report, 1972. ADFG. Unpubl. report. Located at ASA, Juneau, AK.

[48] Simon, Robert J., Jack Lechner, Martin F. Eaton, and Peter B. Jackson. 1969. Kodiak area management annual report, 1969. ADFG. Unpubl. report. Located at ASA, Juneau, AK.

[49] See footnote 47.

sockeye spawning area in the Karluk ecosystem and that placing a weir within this area harmed its adults and juveniles by impeding natural movements. Their conclusions were based on many years of field observations at Karluk during the 1940s and 1950s by Bevan and Walker. Thus, to improve the counting accuracy and to benefit sockeye movements, the ADFG recommended moving the weir to the lower Karluk River:

> [Concerning the Karluk River weir near lake's outlet, 1972] The present Karluk weir location at the lake outlet is not giving the Department a realistic count on red salmon. We know from lagoon tagging experiments that many of the August fish entering the lagoon spawn in the river and do not pass through the weir. We are proposing that the weir be moved to the Karluk Lagoon where more accurate counts can be made.[50]

Though commercial fisheries biologists at ADFG suggested this weir change in 1972, sport fish biologists also preferred the lower river site to aid their studies. For example, in 1972–73 Van Hulle and Murray (1973) wanted a weir on the lower Karluk River to monitor Chinook salmon populations, but they failed to secure a lease for a new site (Murray and Van Hulle, 1974).

The ADFG operated two counting devices on the Karluk River in 1975, the standard picket weir near the lake's outlet and a counting tower on the lower river near the lagoon. At the lagoon tower, inaccurate sockeye counts made this an unsuccessful one-year experiment; the problems they encountered were similar to those of the 1958–59 BCF towers:

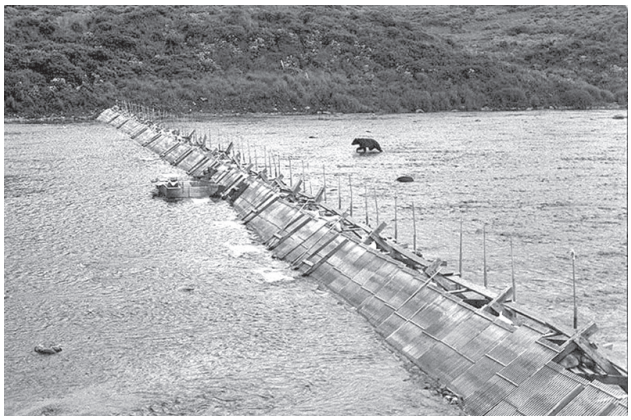
> [At the counting tower on the lower Karluk River, 1975] A cabin, partial weir, flash boards, and counting tower were constructed during the season at Karluk Lagoon. The data obtained from the tower counts proved to be unreliable primarily because of two problems. Salmon passed over the panels during periods of poor visibility and inability to differentiate species of salmon.[51]

Nevertheless, the 1975 counting tower trial was a preliminary step in moving the weir to the lower river. The decision had already been reached that the existing site on the upper river was unsuitable and that a new location on the lower river best satisfied the different interests of the ADFG biologists. Thus, after 30 years of being located near Karluk Lake's outlet, the weir was moved to the lower river in 1976.

Weir near Karluk Lagoon (1976–2010)

The ADFG negotiated a lease with Karluk Village in 1975 to allow a picket weir on the lower river, just upstream from Karluk Lagoon. From 1976 to the present time, the ADFG annually operated the counting weir at nearly the same site on the lower river as that used by the USBF during 1921–41. As expected, the main problem at this location during 1976–2010 was the same as during 1921–41—i.e., even-year pink salmon carcasses drifting against the weir. Weir crews during 1976–2010 once again struggled to clear away pink salmon carcasses in August and September and occasionally removed picket sections to pass the debris downstream (Table 3-1). The ADFG's 1975 experiment with a counting tower was perhaps intended to solve this biennial problem. High river flows irregularly threatened the weir or scoured holes that let salmon pass by uncounted. In some years, bears repeatedly damaged the weir, creating holes that needed timely maintenance to assure an accurate count of the escapement (Spalinger, 2006). In recent years, the ADFG has developed a detailed weir operations manual (Caldentey, 2007, 2009b).

The main purposes of the Karluk River weir during 1976–2010 were to count sockeye salmon and collect run-composition data, but the new location also provided much better information on the other salmonid fishes then being studied (Table 3-2). In particular, it allowed biologists to gather escapement and run composition data on Karluk's Chinook salmon, vital information needed to calculate spawner-recruit relation-



Karluk River salmon counting weir near Karluk Lagoon, 1996. (Richard Lee Bottorff, South Lake Tahoe, CA)

[50] See footnote 47.

[51] Manthey, Ken, Larry Malloy, and Melayna McGuire. 1975. 1975 annual management report, Kodiak Management Area. ADFG, Division of Commercial Fisheries, Kodiak. Unpubl. report. 160 p. Located at ADFG Library, Douglas, AK.

Collecting sockeye salmon scales, Karluk River weir, 1996. (Richard Lee Bottorff, South Lake Tahoe, CA)

ships and to set accurate escapement goals (Nelson et al., 2005). New concerns arose, however, about the effect of the new weir on steelhead survival and movements. Van Hulle and Murray (1977) suggested that the weir may harm spawned-out steelhead by delaying their May–July emigration to the ocean. These downmigrating kelts were in poor condition and delays of a few days or weeks at the weir may reduce their survival. A well-defined method to quickly pass steelhead kelts below the weir was lacking during 1976–91. Begich (1995) concluded that "timely, efficient passage of postspawn downstream migrants in steelhead systems weired for enumeration of immigrating salmon is of paramount importance and greatly assists in facilitation of steelhead emigration." Prior to 1992 the weir delayed steelhead emigration about two weeks, but starting in 1992 a trap was built into the weir to swiftly move kelts downstream. Recent abundant populations of Karluk River steelhead may be partially due to these weir modifications.

The ADFG typically removed the Karluk River weir in mid or late September, well before the entire steelhead and coho salmon runs had entered the river. Van Hulle and Murray (1978, 1979) recommended that the weir be operated until 15 November to get better counts of these two fish species, but this was never done because of logistical problems and deteriorating weather conditions as winter approached. In the 1920s and 1930s, the USBF tried operating the Karluk weir into late October, but abandoned this effort when the weather-related problems became known. Problems with maintaining the weir greatly increased from ice conditions and rising river flows after mid October, often making it hard to remove the weir for winter storage. Weir crews staying into late October often found it difficult to depart because Karluk Lagoon was ice covered, and storms in Shelikof Strait kept USBF boats from landing at Karluk Spit.

Conclusions

This history of the Karluk River weir documents that each of the three weir sites—lower river, Portage, and lake outlet—has certain advantages and disadvantages, some of which have changed with time as different research topics were pursued and logistical problems were solved. Knowledge of these weir sites has been gained by many years of trial-and-error and hard work, by the field efforts of hundreds of biologists and weir tenders, by experiencing a full range of environmental conditions, by field observations of the remarkably dynamic fish migrations, and by discussions between biologists and officials with different research and management interests. After more than 90 years of continuous operation by federal and state agencies, a consensus exists that the lower river is the best weir site, although pink salmon carcasses during even-numbered years may be a problem. This weir site fulfills its main operational purpose of accurately measuring sockeye salmon escapement, but it also provides useful information on many of Karluk's other salmonid fishes. It satisfies the combined concerns and requirements of fisheries management, research, and conservation (Table 3-2).

Despite its times of controversy and various locations since 1921, the Karluk River weir has supplied a tremendous stockpile of fishery and scientific data on its commercial and sport fishes (Figure 1-3). The knowledge gained from this facility, as well as the long-term research at Karluk, has advanced the understanding of sockeye salmon from near complete ignorance in the 1880s to an exquisite appreciation of this complex and dynamic species in 2010. Clearly, the weir continues to be one of the best tools for managing, monitoring, and studying salmonid fish runs in the Karluk River. While the uses of the weir may change somewhat in the future and the operations will be modified and improved, the valuable data gathered each year make it likely this program will continue for many years.