Department of the Interior
United States Fish and Wildlife Service
Bureau of Commercial Fisheries
Alaska Region

SALMON SURVIVAL INVESTIGATIONS

Kodiak Island Red Salmon Investigation
Plan of Operations for 1958 Field Season

BACKGROUND

Investigations of the yearly fluctuations in the abundance of the Karluk Lake red salmon was initiated in 1921 after an extended period of steady decline in the run. Early efforts to maintain the run were principally to control the fishery to obtain a 50 percent or better escapement of the spawning adults as provided by the White Act. A weir was maintained on the lower Karluk River to count the escapement to provide a basis for controlling the catch. After a number of years of observation, it was found that the run was still on the decline and that there was poor correlation between the magnitude of the escapements and the resulting returns.

The research program was expanded to include a study of the biology and life history of the red salmon to search for the causes of the variations in the ratios of returns from known escapements. In 1926 J. T. Barnaby began an investigation of the life history of the Karluk red salmon in both the marine and freshwater environments. From marking experiments over a period of years, he concluded that the marine survival of the Karluk red salmon was about 20 percent and appeared to be fairly constant. Therefore it was decided that the gradual reduction in overall survival and the fluctuations in yearly rates of survival were caused by some factor in the freshwater environment.

The limnology of Karluk Lake was investigated by Juday, Rich, Kemmerer and Mann in 1926[1/]. They found that Karluk Lake was oligotrophic, with certain nutrients in low concentration in the water. They concluded that the supply of decaying salmon carcasses affected to some degree the concentration of these nutrients which in turn nourished the crop of plankton in the water. However, it is evident that the nutrients and the plankton were not considered in short supply or limiting factors on the red salmon during this study, as they concluded their report saying,

> "The large crop of plankton furnishes an abundant supply of food for the young salmon and, as a result, the fingerling salmon of Karluk Lake are unusually large and sturdy."

1/ Juday, C., Willis H. Rich, G. I. Kemmerer and Albert Mann. 1932. Limnological studies of Karluk Lake, Alaska, 1926-1930. Fish. Bull. 12, 47: 407-436.

However, Barnaby[2], speculating on possible causes of the decline in the Karluk red salmon run stated that:

> "Since the concentration of these (nutrient) chemicals in the lake water during most of the summer was less than a measurable amount, it is evident that they must be limiting factors in the production of the phytoplankton and may possibly be affecting indirectly the growth and survival of the red salmon fingerlings of Karluk Lake."

Also during this period several other hypotheses were advanced and investigated to explain the decline in the Karluk run. DeLacy[3] and DeLacy and Morton[4] studied the problem of predation by Dolly Varden and arctic char on the red salmon fingerlings. While their conclusions were that neither of these two species of fish were serious predators, it is felt that their findings on predation, while valid for the period of study, were incomplete as their studies were conducted only through the summer months. Shuman[5] next investigated predation on the adult red salmon by brown bears. This study which was conducted on the small lateral streams of Karluk Lake, indicated that of the considerable number of adult salmon taken by bears, 31 percent were taken before spawning. Hence, he concluded that predation by brown bear was an important factor in the decline of the Karluk red salmon. Later studies by Clark, game biologist at Karluk Lake, on this same problem, showed that rather few salmon taken by bears were in an unspawned condition. This factor is still in doubt.

In 1950, investigating Barnaby's hypothesis, a study was begun of the effect of the addition of artificial fertilizer to lake water on the growth and survival of red salmon. The principal experiment was undertaken by Nelson at Bare Lake, a small shallow red salmon lake at the western end of Kodiak Island. The level of productivity in Bare Lake as measured by the production of plant plankton was increased for a period immediately after each addition of artificial fertilizer. Also during the first years of the experiment there were indications that the growth of juvenile red salmon had increased during the summer months under fertilized conditions. This did not hold true in 1956, the last

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2/ Barnaby, J. T. 1944. Fluctuations in abundance of red salmon Oncorhynchus nerka (Walbaum) of the Karluk River, Alaska. Fish. Bull. 39, 50: 237-295.

3/ DeLacy, Allan C. 1941. Contributions to the life histories of two Alaska charrs, Salvelinus malma (Walbaum) and Salvelinus alpinus (Linnaeus) Ph. D. thesis, Univ. Washington. 114 pp. (typewritten)

4/ DeLacy, Allan C. and W. Markam Morton. 1943. Taxonomy and habits of the charrs, Salvelinus malma and Salvelinus alpinus, of the Karluk drainage system. Trans. Am. Fish. Soc., 72: 79-91.

5/ Shuman, R. F. 1950. Bear depredations on red salmon spawning populations in the Karluk River system, 1947. Jour. Wildlife Mgt., 14(1): 1-9.

year of the experiment. Many of the limnological effects accompanying the addition of fertilizers to Bare Lake were followed in great detail and some of the results have been published. However the relationship of the results of this experiment to the root cause of the decline of Karluk red salmon run has not been established.

The fertilization experiments in overall relationship to red salmon production in Bare Lake must be considered inconclusive as well as not necessarily applicable to Karluk Lake. The principal reasons the Bare Lake experiments are considered inconclusive are:

1. Fertilizer was added to Bare Lake the first year of the experiment without time to sufficiently measure and establish rates of growth and production in the natural condition.

2. There is evidence in the literature that natural fluctuations in the weather from year to year may control the abundance of aquatic insect larvae. Insect larvae are important in the food chain in Bare Lake leading to red salmon production. Weather effects at Bare Lake may have overridden any effects of fertilization on the abundance of the insect larvae during the course of the experiment.

3. Several other species of fish present in Bare Lake may compete for food and for any increase of food that was produced during the fertilization experiment. The numbers of these fish of other species in Bare Lake varied during the course of the experiment. Considerable effort was made to estimate the numbers of fish of other species present. The abundance of stickleback which far outnumbered red salmon could not be estimated. Dolly Varden are known to have steadily increased in numbers. Numbers of silver salmon could not be estimated. Furthermore the total biomass of these other populations of fish averaged at least five times as much as the red salmon.

4. The growth rate of juvenile red salmon which had increased each year in the early stages of the experiment, decreased in 1956, the final year in which fertilizer was added.

The reasons advanced which mitigate against applicability of Bare Lake experimental results to Karluk Lake:

1. Bare Lake is small, shallow and relatively warm. Karluk Lake is large, deep and of a more ideal temperature for rearing red salmon. The two lakes, although adjacent, are on different rivers in separate watersheds.

2. There is evidence that the growth rate of juvenile red salmon in Karluk Lake has not been inhibited by a shortage of food there (Rounsefell[6], also see Juday et al.[7]). This, if true,

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6/ Rounsefell, George A. Factors causing decline in Sockeye salmon of Karluk River, Alaska. MS.

7/ Juday, L., Willis H. Rich, G. I. Kemmerer and Albert Mann. 1932. Limnological studies of Karluk Lake, Alaska, 1926-1930. Fish. Bull. 12, 47: 407-436.

nullifies the applicability of Bare Lake results to Karluk Lake regardless of the results of the Bare Lake fertilization experiments.

3. Red salmon spawners which go up the Karluk River during the long season in that system in the main tend to go to different spawning grounds in the early, midseason and late runs. There is evidence that concentration of the fishery upon the midseason run may have in the long run selectively depleted those subpopulations of red salmon destined for certain spawning gravels. These streams from their size and gravel quality appear to have been the best streams. The concentration of the fishery upon the midseason run and best streams may have in itself tended to reduce spawning success, egg survival, and the ratio of returns from escapement. This hypothetical reduction of returns from escapement would be indistinguishable from survival changes and would occur prior to the arrival of the fry in the lake. Fertilization, by increasing the food supply in the lake, could affect lake survival only, and only if food was in short supply.

Results of the 1957 field season pointed to the importance of investigating the fundamental question of the distribution of spawners to the various combinations of spawning gravels through the season upon survival and returns from escapements.

A keynote of our 1958 research is to find means of comparing the production of fry per unit area from the various spawning gravels of Karluk Lake at known rates of spawning and egg deposition. We are searching for the optimum production of fry by determining the best apportionment of the escapements to the available spawning gravels of the Karluk system at the proper times. We believe this is fundamental, and preliminary to our studies of lacustrine survival in Karluk Lake which are continuing.

OBJECTIVES

A. Adult red salmon spawning escapement

1. To estimate the number of red salmon adults in the spawning migration into Karluk Lake.

2. To estimate the sex ratio, mean length (mid-eye to fork of tail) by sex, the age composition, and the numbers comprising each age class of the migration.

3. To estimate the fecundity of the escapement as a basis for determination of freshwater survival rates from specific brood years.

B. Travel time of the spawning migration

1. To establish the travel time of each portion of the Karluk run through the fishery, up the Karluk River to the weir, and from the weir to the various spawning grounds.

C. Spawning ground studies

1. To estimate the time of arrival, numbers, and distribution of red salmon adults on the various spawning grounds of the Karluk Lake system.

2. To estimate the numbers, distribution, and mean survival rates of eggs deposited at each of the spawning habitats.

3. To continue the measurement of spawning area in the Karluk Lake system begun in 1957.

D. Fry predation and migration

1. To learn the habits of the fry upon emergence from the gravel: their food requirements, their migration, their rate of growth, etc.

2. To determine if the emerging red salmon fry are subjected to serious predation by associated fish species either within the tributary streams and the upper Karluk River or in the lake areas adjacent to the streams.

3. To determine if the red salmon fry spawned in the upper Karluk River migrate into the lake for a period of freshwater residence.

E. Lake resident study

1. To determine the summer diet, the mean growth rate, and the period of maximum growth of the red salmon residents of Karluk Lake by age class.

2. To identify the summer diet of other fish species resident to Karluk Lake and associated with the red salmon to identify possible red salmon predators and food competitors for future study.

F. Seaward migration of red salmon smolts

1. To estimate the total number of smolts migrating seaward from Karluk Lake.

2. To estimate the mean fork lengths, mean weights, and numbers comprising each age class in the migration in order to assess the freshwater growth and survival from specific brood years.

G. Collection of climatic data

1. To continue the collection of the summer climatic data at Karluk Lake to study its possible effect on red salmon survival.

H. Observation of the Karluk District commercial fishery

1. To become familiar with the Karluk commercial fishery.

SPECIFIC OPERATING PLANS

A. Adult red salmon spawning migration

The Karluk River weir, which has been used to count the escapements into the Karluk system since 1921, will not be operated this season. Instead, a system of counting towers will be used to enumerate the spawning escapement. Two towers, one on each side of the river, will be constructed in mid-May. These will be operated throughout the hours of daylight over the entire spawning migration period. The operation will consist of ten-minute counts during each hour of daylight of all species of salmon passing over a submerged wire screen panel. Each species will be recorded separately.

From previous weir operations it has been observed that the migration of red salmon is greatly diminished during the hours of darkness. To estimate the night migration it is planned to occasionally fish the adult trap at night. Also, some experimental night counts will be attempted using lights of various colors and intensities.

To obtain a sample of the adult migration a stationary adult trap with wire mesh wings will be constructed and fished in the center of the river. Every third day from 75 to 125 adult red salmon will be trapped. The entire catch will be used in the sample to avoid any selectivity bias. Each fish in the sample will be measured (mid-eye to fork of tail), sex recorded, scales sampled, and released.

Each year samples of fish from the Karluk escapement are collected for racial studies. These studies include a count of the eggs in the ovaries of the salmon. It is planned to use these counts as a basis for estimating the fecundity of the escapement.

Equipment:

1. Material and tools for tower construction (on hand)
2. Adult salmon trap (on hand)
3. Equipment for sampling adults (on hand)
4. Hand tallies (on hand)
5. Mechanical timers (ordered)

B. Travel time of the spawning migration

In the past there have been tagging studies carried out on the Karluk red salmon run that will give information on their timing and routes of migration. The Fisheries Research Institute tagged Karluk red salmon in the commercial fishery in 1948 and 1949. The Fish and Wildlife Service has tagged red salmon at both the Karluk Lagoon and at the weir site. This year it is planned to begin working up these data. The information gained will be used as a guide in managing the commercial fishery to insure an adequate escapement to the best spawning gravels.

In addition much information can be gained on spawning ground

destination of segments of the escapement by observing peaks of migration at the weir and subsequent peaks of migration to the various spawning habitats.

C. Spawning ground studies

Once each week from late June until early October the adult red salmon will be counted on the spawning grounds by foot survey. The numbers of spawners and their distribution on the spawning grounds by date and by area will be recorded. The lake shore spawning areas will be located and surveyed by light plane at least twice during the season, once each during the spring and fall peaks of spawning.

For measurement of the distribution of spawners, and eggs deposited, the streams will be marked off in 100-yard sections with wooden stakes. Measured areas of the spawning beds within these subareas will be dug for egg deposition counts on a random sampling basis. These samples will be used to estimate the numbers and distribution of eggs deposited in the various spawning habitats. For this operation the egg digging pump apparatus developed by the Fisheries Research Institute will be used. Sampling will begin as spawning activity ceases on the various spawning beds.

Part of the 1957 program included a physical measurement of the spawning areas in the various tributary streams of the lake. This work will be continued this season to include the upper Karluk River and the beach spawning areas. Measurement of these areas will be made by use of a Federal Long Range Rangefinder.

In order for spawning ground surveys to be more meaningful and effective it is necessary to know the average length of time spent on the spawning beds by the adult salmon. At regular intervals groups of salmon will be tagged as they enter the spawning habitat. These salmon will be followed closely and their rate of disappearance from the spawning areas recorded. This procedure will be repeated throughout the season and at each of the three spawning habitats. It is also hoped that information might be gained on the distribution of different spawning waves of adults within the larger tributary systems by this method.

Prior to the entrance of the spawners on the spawning beds, randomly selected small sections of the spawning areas of the three habitats will be protected from spawners by fencing. During the peak of spawning at each habitat, pairs of spawners will be placed within these areas and allowed to spawn. The individual redds will be protected from further disturbance, and will be used in an attempt to estimate egg survival rates at the different spawning habitats with respect to time. One-half of the redds will be dug up at the end of the 1958 season. The other half will be left untouched over the winter and dug early in the following spring. All eggs or fry recovered will be counted, classified as to the numbers alive or dead, the location of the redd recorded, and the survival rates estimated.

An attempt will be made to collect readable scales from adult red salmon from each spawning stream and beach. It is our intent to develop means of identifying these subpopulations so we can trace their passage through the fishery, up the river, and to their final destination.

Equipment:

1. Hand tallies (on hand)
2. Egg digging pump and accessories (on loan)
3. Rangefinder (on hand)
4. Tags and tagging equipment (on hand)
5. Fencing materials to protect redds (on hand)
6. Scale collection materials (on hand)

D. Fry predation and migration

The study will begin early in April after it is established that the red salmon fry are emerging from the gravel. It is planned to capture other fish species associated with the salmon fry within the stream systems and also in the lake areas adjacent to the streams. Both small mesh beach seines and experimental gill nets with five different stretch mesh sizes ranging from 1/2 to 1-1/8 inches will be employed in the collection of the samples. The fish comprising each sample will be measured (fork length), the stomach contents identified, and the numbers as well as the percent of the total volume of each different group of food organisms recorded. Sampling will take place at each of the three broad types of spawning areas, lateral streams, terminal streams (including the upper Karluk River), and the spawning beaches. Any apparent salmon predator thus identified will be slated for a more intensive future study. If the lake is frozen over, only the lower half of the lake from the Thumb system to the outlet will be sampled due to the distance involved. If, however, the lake is clear of ice, an attempt will be made to sample at all spawning sites.

At the same time that the above sampling is taking place, one upstream and one downstream fry trap will be fished in the upper Karluk River. The traps will be moved daily to random positions across the river in an attempt to locate the route and direction of migration of the zero year class red salmon. Since considerable spawning takes place in the upper Karluk River, it would be of value to determine if these fry move into the lake, remain in the river, or migrate downstream from the spawning bed after hatching. The traps will be tended daily, the entire catch counted and released, and the trap position moved until the migration route and direction has been established.

Equipment:

1. Small mesh beach seine (on hand)
2. Experimental gill nets (on hand)
3. Measuring equipment (on hand)
4. Equipment for stomach analyses (on hand)
5. Fry traps (on hand)

E. Lake resident study

Beginning in June the lake resident fish species will be sampled once every 10 to 14 days. The littoral zone will be sampled by both small mesh beach seine and experimental gill nets with five stretch mesh sizes ranging from 1/2 to 1-1/8 inches. The pelagic area will be sampled by experimental gill nets and a small mesh tow net. The catches will be compared for numbers, species, and age composition. The gill net catches will be used to give a catch per unit of effort to establish broad habitat preference over the season in the different parts of the littoral zone and pelagic zone. Each catch will be recorded as to location, method of capture, length of fishing time (or number of tows), and numbers of fish captured by species. Fork length measurements will be taken from all red salmon juveniles captured. The entire catch at each location will be combined and ten fish samples from each species will be split from the total catch. These samples will be used for summer food studies by species. The fish comprising each sample will be measured (fork length), scales sampled, and the stomach food contents analyzed and recorded by number and percent of total volume per grouping of organisms. In effect this will be an extension of a portion of the fry study that began in April. Possible red salmon predators and food competitors will be identified for future study.

Equipment:

1. The same equipment that is used in the fry study will be used for this study. All equipment will be on hand.

F. Seaward migration of red salmon smolts

The seaward migration of red salmon smolts will be sampled this year in such a way as to provide an estimate of the total number migrating. The method used in the past has yielded an index of abundance rather than an estimate of numbers.

The Karluk River will be divided in width into 12 equal sections of approximately 21 feet per section. An easily dismountable smolt trap with 10-foot leads and a 7-foot width will be constructed in the center of each section. The sections will be trapped continuously one at a time for two-hour intervals on a Latin square design basis. In this way each section will be sampled once every 24 hours and an estimate of the total number of smolts migrating can be gained.

For an estimate of the numbers, mean lengths, and mean weights of the smolts comprising each age class in the migration, it is planned to obtain a sample of 80 smolts from the trap catches every third day. The sample will be taken in four sub-samples of 20 smolts each. Each sample day, 20 smolts will be taken from each of four periods in time. Twenty will be taken from an accumulation of the daylight catches between 8 A. M. and 4 P. M., 20 from the 8 to 10

P. M. catch, 20 from the 10 to 12 P. M. catch, and 20 from either the 6 to 8 P. M. or the 12 to 2 A. M. catch, dependent upon an early or late outset of migration each evening. Each sub-sample will be removed by splitting the entire catch of the trap from which it is to be extracted, and processed separately. Each smolt in the sample will be weighed, fork length measured, scales sampled, and released. The entire catch from each trap will be counted, recorded, and then released.

In the past the smolt traps have been operated from mid-May through mid-July after which time the smolt migration usually drops off. This year the traps will begin operation on May 1 and continue operating on a limited basis after July 15 until the migration has been completed.

Equipment:

1. All materials for construction of the traps (hardware cloth, fence posts, wire, tools, etc.) are on hand already at Karluk.

2. Smolt measuring and scale sampling equipment (on hand)

G. Collection of climatic data

A standard U. S. Weather Bureau field station has been operated at Karluk Lake using Weather Bureau equipment for the past few summers. Data collected daily are air and water temperatures, both maximum and minimum, rainfall in hundredths of inches, wind direction and velocity, and barometric readings twice daily. The collection of these data will be continued this season.

Equipment:

1. All equipment is furnished by the U. S. Weather Bureau and is already on hand at Karluk.

SAFETY PROGRAM

At the beginning of the season the following safety program will be presented to, and discussed with entire crew.

A. Boats

1. All personnel will be required to wear life jackets at all times while operating or working from boats.

2. Each boat is to be checked for an adequate supply of fuel, spare spark plugs and wrench, and a pair of oars before leaving the mooring.

3. The boats are to be operated at a safe speed and distance from obstructions at all times.

B. Rifles

1. Each man will be thoroughly instructed on rifle safety by the project leader before he will be allowed to handle firearms, either personal or government owned.

2. Rifles will be kept unloaded in the camp area and in the boats en route to the study areas. They may be loaded as instructed (cartridge in the magazine only, chamber empty) after landing in the area where bears may be encountered. They will be unloaded before re-embarking or returning to camp.

3. The man carrying the rifle for bear protection, where needed, shall walk in advance of the other men in the crew. Crew leaders or experienced men only should carry rifles until all are familiar with bears.

4. The entire Karluk area is within a Federal Wildlife Refuge. Bears may not be molested, and under no circumstances may they be shot except to save a life.

C. Camp Safety

Fire protection:

1. No smoking where gasoline is stored, or when filling lanterns or gasoline motors, etc.

2. All personnel will be instructed in running the gasoline water pump and attaching the fire hose.

First aid:

1. First aid kits and instructions will be kept in supply.

D. General

1. All operations and activities must be carried out in a safety conscious manner. Any employee who wilfully disregards safety rules will be subject to dismissal.

2. The crew leaders will be directly responsible for the safe conduct of their crews and activities.

SCHEDULE OF OPERATIONS

A. Personnel and program schedule

April 3 - 15	Raleigh and Conkle depart from Juneau for Karluk. Camp opened and fry study begun.
April 16 - 30	Construction of smolt traps and fry study continued.

May 1 - 31	Owen arrives at Karluk. Smolt sampling begins and fry study continued. Construction begun on counting towers.
June 1 - 30	Two temporaries arrive at Karluk. Fry study ended. Smolt sampling continued. Adult enumeration and sampling begun. Lake resident study begins.
July 1 - 15	Four temporaries arrive at Karluk. Smolt sampling continued. Adult count and sampling continued. Spawning ground studies begun. Lake resident study continued.
July 16 - 31	Smolt sampling on a reduced basis. Adult count and sampling continued. Spawning ground studies and lake resident study continued. Raleigh to Juneau.
August 1 - 15	Smolt sampling ended. Other studies continued.
August 16 - 31	Raleigh to Karluk. Studies continue.
September 1 - 15	Four temporaries return to Seattle. Lake resident study ended. Adult count and sampling continued. Spawning ground studies continue.
September 16 - 30	Two temporaries to Seattle. Studies continue.
October 1 - 15	Studies ended. Camp closed. Owen, Raleigh, and Conkle to Juneau.

B. Supply equipment needs

1. Supplies delivered to Kodiak prior to May 15 via the Service vessel DENNIS WINN. Transshipped to Karluk via Service aircraft or to Zachar Bay via Service vessel KITTIWAKE.

2. A weekly supply trip from Kodiak to Karluk from April 5 through October 15. Both commercial aircraft and Service Grumman Goose aircraft will be used.

PERSONNEL ASSIGNMENTS

A. Permanent

1. Project leader, John B. Owen, general supervision and coordination.

2. Assistant project leaders, Raleigh and Conkle, supervision, training, and placement of seasonal employees, supervision of specific studies.

B. Seasonal

1. Six seasonal employees will be employed this year.

REPORTS AND DATA

A weekly report of progress and significant results will be submitted by the project leader to Juneau. A summary report of field operations, including all data worked up to date, will be due at the end of the field season.

Submitted by:

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May 21, 1958