BEAR-SALMON STUDY, 1952: BROWN'S RIVER, UYAK BAY, KODIAK ISLAND, ALASKA

by
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Regional Director, FWS, Juneau, Alaska January 12, 1952

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Tranmittal of BEAR*SALMON report by John E. Lutz.

Transmitted herewith is the report by John E. Lutz, Wildlife Management Biologist, of field investigations at Brown's Lagoon, Uyak Bay, Kodiak Island, concerning the relationship of the Kodiak Brown Bear and pink Salmon.

Brown's Creek (Brown's Lagoon) was chosen this year for the pink salmon-Kodiak Bear relationship study because of the locality of the stream, type (size and depth) of stream, and the migration of pink salmon. Heretofore, all bear-salmon work had been done on small shallow streams at different places on Kodiak Island. This stream was chosen because it was somewhat larger with a greater run-off of water than streams studied in previous years. Then too, this stream is in the heart of bear country. The number of fish expected to migrate into the river was estimated at approximately 90,000 by Mr. Roy R. Lindsley, Fisheries Management Biologist, however, the tremendous run of pink salmon effected the streams on the Shelikoff side of Kodiak Island by an increase of the number of fish in each system. Brown's Creek was not excluded having a run of 136,00. As a general rule, pink salmon spawn on the Shelikoff side of Kodiak on the even years and on the Pacific side on the odd years. Other streams were considered for this study but information relative to numbers of fish that could be expected was uncertain; for example, a small run of fish generally over the area, would have a greater influence on these other smaller streams. The migration habits of the pink salmon had to be taken into considration as these fish hit the streams suddenly and in large numbers. Several days of moving from one bay to another after the runs had started would have caused a delay that would limit a satisfactory weir operation. All steams except Brown's Creek on this side of the island are affected severely by the huge tides causing a great amount of trouble with the operation of weirs near the mouth of the streams. Brown's Creek with the falls at the mouth was not affected except at the extreme high tides.

The study shows a relatively small number of unspawned salmon taken by bear. Although the figures are not as exact as those of the Sulua Creek study, the number represents similar condlusions. This study brings out the fact more clearly that the vegatative feeding habits of the bears has an affect upon the number of salmon taken.

In all studies, observations have shown that the elderberr and other berries ripen during the first part of August and that this type of vegatative food shows predominately in the droppings of the bear by August 15. When considering the dates of the runs of salmon in the stream, there is only a period of about 15 days after the pink salmon are in the stream before the berries are suitable for food for the bear. Also, during this period the salmon are fresh and not as vulnerable to capture. After the fish become concentrated in the stream and are not as fresh, they become more available to the bear, but the food habits of the bear has changed at least in part.

January 12, 1953
Regional Director

It is felt that the data on pink salmon mortality from bear was sufficient from the Sulua Creek study in 1952, and that another studysimilar in nature to that study of this one on Brown's Creek will not be conducted this next season.

Russell R. Hoffman

cc Spencer

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UYAK BAY,
KODIAK ISLAND,
ALASKA

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CONTENTS

1. INTRODUCTION

This study on the relationship between pink salmon and the Kodiak brown bear was a continuation of the work begun last summer (1951) by W.K. Clark, Biological Aid, Fish and Wildlife Service.

Work on red salmon by Shuman (1950) and Lutz (1950) showed an unspawned bear-kill to be 31.3 and 18.3 per cent respectively. The work by Clark showed that the bears took an estimated 1.02 per cent unspawned pink salmon from an escapement of 10,895. This "bear-killed unspawned salmon" percentage appeared extremely low when compared with the figures from these other studies.

For this reason and because other data would enforce the estimates made by Clark, this present study was planned.

Brown's River (Figures 1,2, and 3) was chosen as the site for this study because it was expected to have an escapement of approximately 90,000 pink salmon and because a weir could easily be installed on the river. Brown's River flows into Brown's Lagoon which is located on the eastern shore of Uyak Bay, Kodiak Island. Commercial fishing is not permitted within the lagoon and as the average tides leave a good deal of water within the lagoon, the salmon are relatively protected before they enter fresh water.

Note: No scientific names are included in the text. These may be found in Appendix 4.

Normal low tides bare a small waterfall series at the mouth of the river over which the salmon experience difficulty ascending. The waterfall drops about 12 feet at mean low water.

The river averages about 65 feet in width and about 30 inches in depth; it extends into the head of it's valley for over two miles. A series of waterfalls about 1 3/4 miles from the river mouth prevents all but a few salmon from going further upstream (Figures 1 and 2).

Excellent gravel spawning beds throughout the stream are interrupted occasionally by deep silted pools and rocky riffles. Late in the summer the increased rainfall plus the activity of the salmon, bears and other animals makes the stream somewhat muddy and the algae-covered rocks and gravel become silted.

The river is fed early in the summer by the melting snow and the drainage from the surrounding mountains. During mid-summer the main source of water is the run-off from the mountain slopes surrounding the valley and the lessened rainfall (Table 1) reduces the stream level 9 to 12 inches. This reduced flow is very likely a helpful factor in warming the stream.

The river is bordered throughout much of its length by willow thickets but the lower portions are relatively brush-free. The abundant Blue-joint grass is found throughout the stream valley and other grasses are interspersed. Sedge patches occur in low spots along the river. Alder and Cottonwood growths are common but not so widespread as the willow on the floor of the valley. The Parsnip family is represented by Sea-Coast

Angelica, Water Hemlock, Cow Parsnip, and other plants. Fireweed patches were abundant and after the first frosts, redden the landscape. Elderberries and Highbush Cranberries are common.

Not over 6 hair seals frequented the immediate vicinity and sea lions were not seen until late in the season. Weasels and voles were abundant, fox common, and land otter present. Snowshoe hares were not observed but scattered sign was noted. Bears were common to abundant. Several species of ducks nested in the area but their numbers were not excessive. Eagles were common, seagulls abundant, and song and shorebirds of numerous species abundant. Three species of salmon (pink, silver, and red) ascended the river but only pink salmon were present in appreciable numbers.

2. CONSTRUCTION

A. WEIR

The weir was constructed in sections to enable quick erection in the field. The 1 by 4 inch pickets were 8 feet long and were bolted in 2 foot wide sections by using 2 by 4 by 4 inch blocks as spreaders. The tripods were cut and beveled in town and were made from rough 4 by 4 inch timbers. Stringers were also cut from 4 by 4 inch timbers.

It is estimated that a total of 64 man-hours went into the initial assembly of weir materials.

These were then transported via the Shearwater II to Brown's Lagoon by Acting Refuge Manager Hoffman and Boat Operator Foster. This work entailed some 32 man-hours.

The writer was initially working at Karluk Lake, Kodiak Island, on fencing experiments but due to the late arrival of W.K. Clark and the fact that salmon had begun to ascend the river, he was assigned to the present study and flown to Brown's Lagoon on July 21 by Refuge Supervisor Spencer and Acting Refuge Manager Hoffman in Grumman Widgeon 701. The weir material was hauled from the Shearwater II to the weir site, the tripods assembled and set, the stringers set and the picket sections installed on July 21. The following day the pickets were secured, a walk was built and other basic work was completed. Four men, Spencer, Hoffman, Foster and the writer worked a total of 42 man-hours on this portion of the weir construction. A total of about 138 man-hours was needed to install the basic weir (Figures 3, 4, and 5).

Thereafter, various refinements were added and repairs made as needed by Boat Operator Foster and the writer.

B. TENT

A tent platform was constructed along the shore of the lagoon (Figure 2) and the tent erected on July 30. Camping equipment and personal gear were then moved from the Shearwater II to the tent where the writer

and his wife lived the remainder of the summer.

3. PERSONNEL

Acting Refuge Manager Russell R. Hoffman, Boat Operator Paul K. Foster, Biological Aid Frank Toon and the writer worked on the initial assembly of the weir in town. Hoffman and Foster transported the weir materials to Brown's Lagoon and were assisted by Refuge Supervisor David L. Spencer and the writer in its installation.

After the initial assembly, Foster aided in tallying the escapement when the run was heaviest and helped repair the weir as needed. Lieutenant Commander Matacsynski and his son helped to place sand bags along the weir to minimize wash-outs. Late in the summer Mr. Joe Maxwell assisted on a stream survey. The writer's wife, Ann, aided immeasurably with escapement counting and dead fish tallying.

4. METHOD OF STUDY

A. ESCAPEMENT COUNTS

The daily count of pink salmon ascending the stream began on July 22. Several thousand fish had ascended the stream before the weir was installed and these were estimated from the air by Mr. Donald E. Bevan of Fisheries Research Institute using Grumman Widgeon 701. The weir was broken

by high tides five times and once an uncounted number of salmon went upstream while several picket sections were removed in an effort to repair the damage caused by an extremely large number of dead fish pressing against the face of the weir. The counts and estimates of the pink salmon escapement are given in Table 2.

Silver salmon began to ascend the river on August 29 and the run reached a peak on about September 15. These salmon are not included in any of the figures given in Table 2. Their numbers did not exceed 500 and a negligible number of dead silver salmon were tallied at the weir. The run appeared to be finished when the weir was removed on September 22.

B. DEAD SALMON TALLY

All dead salmon which reached the weir were tallied, as explained below, for cause of death, spawning condition, and sex.

a. Cause of death

Four groupings were used here: natural death, bear-marked, seal-marked and unknown death. Fish which died without any marks of violence, because of fungus, or because of seagulls pecking, were placed in the natural death grouping. Fish which showed indications of bear-activity such as teeth marks, claw marks and missing portions were placed in the bear-marked category (Figure 7). Salmon which appeared to be quite fresh and which evidenced wounds typical of seal attacks were placed in the seal-

marked group. All salmon which could not be added to any of the above three categories with any assurance of accuracy, were placed in the unknown category.

Fish which have, in the past, been termed "bear-killed" by Shuman and "bear-taken" by Clark are, in this study, termed "bear-marked". Many live salmon are caught and eaten but others, particularly when salmon are scarce in the stream, will be bitten, clawed or eaten by bear after they have died naturally. These could not be termed "bear-killed". It is known that bear will claw or bite salmon which then escape and spawn, but these could be called neither "bear-killed" nor "bear-taken". It may be argued that this is merely a case of semantics; in any event, this "bear-marked" category is used here in an attempt to arrive at accurate terminology. The same argument applies to the use of the "seal-marked" grouping.

b. Spawning condition

One exception to the previously used methods was followed. Rather than place the dead fish into three spawning condition categories (spawned, unspawned, and unknown) as was done in the past, four categories were used (spawned, partially spawned, unspawned, and unknown). It is felt that a more accurate description of the situation is obtained by adding this "partially spawned" grouping.

It is extremely difficult to determine if a male salmon has spawned.

Many males, after spawning with one female, have not exuded one-half the available milt and would thus appear to be unspawned were they to die or be killed. Unpublished Fisheries Research Institute studies indicate that one male can fertilize as many as ten females under natural conditions. Consequently, the past method of classifying males as either spawned or unspawned on the basis that they retained more or less than one half their original milt has probably given a false impression of the actual situation.

This new category should lessen the error somewhat in preventing at least some of the males from being mis-classified. Even with introduction of this new grouping there will be male salmon which are actually more spawned-out than they appear. Females present little problem in this respect.

Fish which could reasonably be assigned to a known spawning category were classified as spawned if more than 2/3 of the eggs or milt had been expended, as partially spawned if from 1/3 to 2/3 milt or eggs remained and as unspawned if more than 2/3 milt or eggs remained, (Figure 6). Certain carcasses which, because they were partially eaten by bears or because of decomposition, lacked gonads and others especially females which lacked eggs but which may not have spawned, were placed in the unknown category.

c. Sex

In all but a few cases the sex of the salmon was obvious. Some-

times, however, only a part of the cranium was left because of decomposition and this could not be assigned to either sex with assurance. In other instances, fish which were eaten by bear when they were fresh from salt water proved difficult to identify for sex. The male salmon, when it is fresh, has no well-developed hooked snout and the bears often eat fish quite completely, leaving only a lower jaw, liver, and gonads if the fish is a male. In such a situation, if the jaw is separated from the gonads, identification is virtually impossible. Consequently, three groupings were used here: male, female, and unknown.

C. BANK TALLIES

In 1951 Clark made numerous tallies of the dead fish along the Sulua Creek bank above the weir and in so doing, arrived at an exceptionally accurate dead fish count. It was expected that this would be possible here but with the large escapement a good deal of the writer's time was spent at the weir. Further, the lower portions of the stream were relatively open but the upper two-thirds of the stream bank was a dense growth of willow and alder (Figures 9, 10, and 11). The writer went more than halfway to the upper spawning limit at the beginning of the study but thereafter did not feel it was safe for one person. The bank survey work, of necessity, requires that the majority of one's time be spent watching the ground for

tracks and looking through the high grass for salmon remains; one cannot do this properly and still be on the look-out for bear. Consequently, bank surveys were not successfully done.

Boat Operator Foster anchored the Shearwater II in Brown's Lagoon during most of the summer, but he did not feel sure enough of his handling of a rifle to enter into any situation where his life might depend on it.

Therefore, the writer went upstream several times alone but only the lower half of the spawning portion of the stream was traversed. Late in the season Mr. Joe Maxwell, living near Harvester Island in Uyak Bay, kindly consented to accompany the writer on a stream survey and Foster went also.

Further, with the large number of salmon which entered the stream, it would have been impossible for one man to make as thorough a study as that made by Clark at Sulua Creek even if the escapement had been no larger than the expected 90,000 salmon and all others factors permitted constant bank observations.

D. CORRELATED WORK

Additional work was done in conjunction with this study and this will be discussed below.

5. RESULTS AND DISCUSSION

A. ESCAPEMENT

In general, this study was conducted along the same lines as used by Shuman and Lutz. Daily counts were taken of the escapement by means of a weir from July 22 through September 22. The dead fish which floated downstream were caught by this weir and were tallied with respect to cause of death, spawning condition, and sex.

The pink salmon escapement totalled 136,390. Silvers and an occasional red salmon entered the creek but their numbers were exceedingly small and because the study was made for information on pink salmon, their inclusion here is not felt necessary or worthwhile.

There were apparently two runs of pink salmon which entered the river. The first and larger of the two began entering the stream on about July 18, reached a peak July 25, and ended on August 9. The second and smaller run began on August 18, reached a peak about August 27, and ended September 12.

The second run did not enter the river until after swimming about the lagoon for some time; therefore these salmon, when they entered the river, were not as fresh as the fish of the first run.

B. WEIR TALLY

Of the 136,390 pink salmon ascending the stream, a total of 33,043 (24.2 per cent) dead fish drifted back downstream, and were caught by the weir and tallied. The totals of the various categories are shown in Table 3. The complete data is not included in this report

because it is felt that it is not necessary to an understanding of the situation (Appendix 1).

In order to compute the estimated percentage of bear-marked, naturally dying and seal-marked salmon, the fish originally tabulated in the unknown groupings were placed in known groupings by means of the percentages of fish already in those known categories. The method used in doing this was involved and is, therefore, explained in the appendix rather than here (Appendix 2). Table 4 shows the totals in the various known categories after the above mentioned computations were completed.

a. Naturally dying salmon

The vast majority of the fish dying naturally were spawned. Of those which were either partially spawned or unspawned, much blame can be laid to fungus. This first developed, typically, just anterior to the anal fin and extended upward and foreward to form a growth on either side. As this is the place that copepod parasites commonly attach to the fish, it is probable that this portion of the fish is subject to less intense water flow during swimming than the rest of the body surface.

The fungus had an appearance similar to a thin layer of submerged cotton. After this initial growth was established, the fungus spread over the entire body surface, often excepting the head.

Unfortunately, the writer's thermometer broke early in the summer and temperatures could not be correlated with the fungus growth, but it was

observed that the fungus appeared and flourished as the water became warm.

The spread of the fungus was facilitated by the concentration of salmon and almost every fish that died, from any cause, had some fungus growth.

Seagulls did not harm the salmon in this study to the extent that occurs on smaller and more shallow streams. At the beginning of the summer, seagulls were concentrated around the shore of the lagoon and at the mouth of the river. Later they frequented the more shallow parts of the stream. They did not appear to damage unspawned salmon in any significant degree.

The weir caused the death of a number of salmon, particularly females, during the peak of the run. During the late afternoon and evening the fresh salmon tended to drift downstream and the females, heavy with eggs, were pounded against the weir face and often the current held them there to die.

b. Seal-marked salmon

Very few seal-marked salmon were tallied and the majority of these were unspawned. It is probable that these did not get far above the weir before dying. The seal-marked salmon which swam to above the weir usually were bitten on the underside and thus were not typical of

bear-marked salmon. Seal were not as numerous in the area as the large salmon numbers might indicate because of the many persons visiting the region who shot at them.

c. Bear-marked salmon

From Table 4 it can be easily seen that an exceedingly small number of tallied salmon were bear-marked. The total number marked by bear was 681 or slightly over 2 per cent of the entire sample. The vast majority (631) of these bear-marked salmon were spawned at the time of their death. This leaves the remarkably small number of 50 which were either partially spawned or unspawned. Further, the great majority of this latter number were at least partially spawned, leaving but 13 salmon which were tallied as bear-marked and unspawned.

d. Discussion

Clark concluded that 1.02 per cent unspawned salmon were taken by bear. He used only two known categories: spawned and unspawned. In order to compare the present work with his figures, the partially spawned salmon group can be halved and one half the number of partially spawned salmon added to the unspawned group. By doing this, it is computed that 0.09 per cent of the total sample was bear-marked unspawned. It is emphasized that this figure should be used for comparison purposes only and that, as ex-

plained previously, some of the fish included in this figure are probably completely spawned and many others partially spawned.

This number of less than one-tenth of one per cent applies with surety to only the lower one-half of the river used by salmon. This portion of the river was visited periodically by the writer and the dead fish arriving at the weir appeared typical of those found in this section of the river. The upper half of the river was visited only once; on September 19. At this time only about 25 live salmon were seen in the river. The upper portions of the stream were completely different from the lower half; the bear activity appeared to be concentrated in this upper area and a much greater number of dead salmon were seen along the banks.

At the time of this survey no freshly killed salmon were seen. All the dead salmon on the banks were reduced to skeletons by fly larvae and nothing could be learned of their spawning condition.

Consequently, the figures derived from this study are applicable only to the lower one half of the stream where the bear activity was least. The figures, therefore, are of little value in respect to an estimate of bear damage on the entire river system.

It is felt that the bear activity was no more than 10 times greater in the upper half of the river than in the lower half. Assuming that there was this ten-fold increase in activity on the upper portions, the following is calculated:

At the weir, 681 salmon or 2.06 per cent of the total number tallied were bear-marked; this applies to the lower one half of the river. Multiplying this percentage by 10 gives 20.6 per cent bear-marked salmon in the upper half. By adding these two percentages and then dividing by two, an average of the bear-marked salmon along the entire river is obtained: 11.33 per cent.

It is not felt that the bears take an appreciably greater percentage of unspawned salmon in the upper than in the lower half of the river. From Table 5 it is seen that of the bear-marked salmon, 1.9 per cent are unspawned and 5.4 per cent are partially spawned. It is thought that these percentages approximate the true bear-marked salmon percentages in the upper half of the river. In a river as wide and deep as the one under consideration, fresh and unspawned salmon are lively and can usually escape to deep water quickly if pursued by a bear. Conversely, spawned salmon are relatively inactive and sluggish and make easy prey for the bear. It would be expected, therefore, that in any drainage system where the waters are relatively deep, the bears would experience considerable difficulty in catching fresh, unspawned salmon. This is confirmed by observations.

In addition, it is entirely possible that salmon found in the upper regions of the river are more spawned on the average than those closer to the stream mouth. If this is the case, bear would have a

smaller chance of catching unspawned salmon near the head of streams even though the salmon are more easily caught.

An estimated amount of bear damage on Brown's River can be obtained by applying the percentages derived above. The total number of bear-marked salmon are estimated at 15,453 (11.33 per cent of 136,390). The unspawned salmon in this group total 294 (1.9 per cent of 15,453) and the partially spawned salmon total 834 (5.4 per cent of 15,453). Thus, if the preceeding assumptions are accepted, 1,128 salmon are taken before they have completed spawning. This number, in an escapement of 136,390 pink salmon is negligible.

The reader is reminded that these latter numbers are not to be taken as true estimates; they are based too much on supposition to afford accuracy.

The following percentages are taken from Table 5.

Natural death	Spawned	87.61%
	Partially spawned	5.66%
	Unspawned	6.73%
		100.00%
Bear-marked	Spawned	92.66%
	Partially spawned	5.43%
	Unspawned	1.91%
		100.00%

Of the fish dying unspawned and partially spawned, it should be noted that the percentage is higher in the natural death category

than in the bear-marked category.

If bears were selective in that they took more bright and fresh salmon as has been claimed in the past, the figures would be entirely different and should show a higher percentage unspawned fish in the bear category than in the natural. It is probable that a certain percentage of the unspawned fish marked by bear would have died unspawned naturally.

The same thought applies to the partially spawned fish marked by bear. These percentages can be obtained from the excerpted data above.

In this study, such a correction would result in only a small (about 6 per cent) reduction in the bear-marked unspawned and partially spawned salmon. In other cases this correction might affect the conclusions about the degree of bear damage to a much greater degree.

C. CORRELATED WORK

a. Plant collection

In conjunction with this work, a plant collection was made in order to supplement the Kodiak office herbarium.

b. Mammal collection

Much time was devoted to trapping small mammals in the area in an attempt to develop a mammal survey of the island. Only two species were taken: tentatively, the Kodiak meadow mouse and the Kodiak Island weasel. Foxes, hares, land otter and the bear were present but not trapped. Reports were received concerning bats which apparently frequent an abandoned barn in Larsen Bay but no opportunity was available for collecting these.

c. Bird tally

Notes were taken on the birds seen in the area and a list of these is given in Appendix 3.

6. BEAR FEEDING HABITS

A. DROPPINGS

When the writer first arrived at Brown's River, the droppings consisted primarily of grasses and Sea-Coast Angelica. Soon after the first salmon entered the river some droppings showed slight amounts of salmon and later, from August 8 up until August 15, salmon made up the

major portion of the droppings. After this date, Elderberries and Highbush Cranberries became more numerous and by August 20 were the major constituents. Small amounts of sedge were seen in the droppings throughout the summer.

B. OBSERVATIONS

The first bear seen were along the river attempting to catch the fresh salmon. Three bears, two adults and one sub-adult, were observed within a distance along the stream bank of 150 yards on August 3. During the half hour these animals were observed none caught any salmon although numerous attempts were made. This enforces the claim that bears experience great difficulty in obtaining live salmon, before the fish have spawned, where the water is not shallow. One bear wandered to within 150 feet of the weir but apparently paid no attention to it.

Late in the season several bear were seen to pull dead salmon from the river and eat them. One young bear that habitually fished about 200 yards upstream from the weir was often seen pulling dead fish from the shallow water near the bank. Usually this bear pulled the salmon to the surface and looked at it. When the salmon appaared firm the bear took it to the bank and ate it; when the salmon appeared macerated or too spoiled, it was dropped and another fish pawed out.

Often, even when the salmon were available, the bear were seen to

eat grass and sedge while plodding along the banks.

C. FOODS EATEN

a. Grasses

Blue-joint
Meadow Barley
Sea Lyme-grass
Bluegrass

Blue-joint is the most common grass on Kodiak Island and was much eaten by the bear up until the salmon entered the river. Bluegrass and Meadow Barley were noticeably eaten along the stream banks and Sea Lyme-grass was often eaten where it was found but this latter grew mostly along the high-tide line of Brown's Lagoon.

b. Sedges

Alaska Long-awned Sedge
Merten's Sedge
Lyngbye's Sedge

Sedges were not common in the area; only a few moderate-sized patches were seen along the stream but these were well-utilized. These appeared in the feces in small amounts throughout the summer. Clark(1951)

found that sedges were extensively eaten, but in the area of his study sedges were abundant and such was not the case here.

c. Fruits

Elderberry
Highbush Cranberry
Salmonberry
Clasping-leaved Twisted Stalk
Domestic Raspberry

Elderberries began ripening about the first of August and were first noticed in droppings on August 10. Thereafter, they were taken in large amounts through the end of the study. The berries ripened earlier on south-facing slopes and in relatively open areas than on north-facing slopes and in dense growths. This afforded berries which ripened at different times and provided a long period of availability.

Twisted stalk was rare in the area but it was occasionally found eaten. Raspberries were planted by homesteaders who then moved; these plants are now growing without cultivation and one bear was seen eating the berries.

d. Other plants

Sea-Coast Angelica
Water Hemlock
Cow Parsnip
Nootka Lupine
Horsetails

Early Blueberry
Crowberry
Devil's Club
Willow

These are listed above in order of importance in the area under consideration. Angelica was commonly eaten and some Water Hemlock plants were found chewed. Cow Parsnip plants in this area were well developed at the time the study began but in shaded places some plants were found which were yet small and tender. It was these which showed signs of being eaten by bear.

Horsetails were common in the area and some growths appeared to have been grazed. Horsetail remains were found in few feces.

The remaining plants listed above were found eaten, presumably by bear, but evidence was not obtained from feces examination to prove this. Crowberry, Blueberry and Lupine were common in the region but only rarely was any evidence of grazing seen. Devil's Club was rarely seen and in only one instance was it suggested that bear had been feeding on it.

e. Other food materials

Birds and several species of mammals are common in the area. Sea gull remains were often found along the stream bank but it is felt that these are taken by foxes rather than bear. Weasels and voles are

common but there was no indication that either was taken by bear. Arctic hares are found in the area but only foxes are known to prey on them. One land otter tunnel along the river bank was found dug into, but there was no evidence that the bear which did the digging caught an otter.

One spot was found where a bear had dug into a nest of ground-nesting bees; pollen clumps were scattered about the digging. The fact that bear eat bees and dig into their nests has been mentioned in previous reports. Bark was torn from a freshly fallen cottonwood tree and appeared typical of bear-work. No bark was lying on the ground so the bear apparently ingested this. One dropping was found along the stream which contained a considerable amount of gravel in it with the individual stones as large as 1/2 inch across. This may have been taken incidental to the eating of a salmon but the stone sizes suggest that they were not accidently swallowed. It has been reported many times that bears feed on bark, and droppings containing stones were noted last year at Karluk Lake.

7. POPULATION

It was hoped that an idea of the population size might be obtained but this was not possible due to the fact that only one visit was made to the upper reaches of the river. Most of the bear were con-

centrated in this upper area.

At least five different bear were seen along the lower portions of the stream. Three were adults and two were sub-adults. No females with cubs were seen and it is presumed that they frequented the upper portion of the river.

It is doubted that more than 40 bear inhabit the drainage and the actual number probably lies between 15 and 40. There is little to substantiate this belief; it is merely an opinion.

Track measurements were taken whenever possible but these are difficult to interpret. One bear may make tracks varying as much as 1/2 inch in width. Only the fore paw prints were measured as the hind foot tracks are seldom clear or consistent. The best tracks were found in silted places left dry by the low water level of the river. At these spots the tracks were numerous and usually well defined. Because bear of the same age class may well have similar-sized tracks, a great number of tracks of comparable size may mean either intensive use of the area by one bear or occasional use by many bear.

It is felt that commonly a bear confines his fishing to one particular area but some have been seen wading in the stream for more than 1/2 mile. The older bears probably forage more widely than the sub-adults and these more than females with cubs.

The interpretation of track measurements is, therefore, difficult. When only a few bear are present in an area, an estimate of their numbers may reasonably be made from track measurements. When the probable number is high, tracks appear to be of little help for the reasons given above. It is felt that the marking of bear and the subsequent use of Lincoln's Index is the most practical method of determining populations in a large area. As tracks are of little use with large populations, bear marking would be the less practical method with small populations.

8. SUMMARY

This study on the relationship between pink salmon (Oncorhynchus gorbuscha, Walbaum) and the Kodiak brown bear (Ursus middendorffi, Merriam) was a continuation of the work begun at Sulua Creek in 1951 by W.K. Clark, Biological Aid, Fish and Wildlife Service. Clark found that 1.02 per cent unspawned salmon were taken by bear from an escapement of 10,895.

The present study was conducted at Brown's River, Uyak Bay, Kodiak Island. An escapement of 136,390 pink salmon was tallied and an insignificant number of other salmon ascended the river.

A total of 33,043 dead fish were examined at the weir for cause of death, spawning condition, and sex. The great majority of these fish

were males. Over 97 per cent (32,304) of these dead fish died naturally, slightly over 2 per cent (681) were marked by bear and less than 1 per cent (58) were marked by seals.

The main interest at present lies in the number of salmon taken or marked by bear before spawning as the loss of these fish, if their numbers are too high, might endanger the future salmon runs. It was found that of the total dead fish tallied, 0.11 per cent were bear-marked, partially spawned and 0.04 per cent were bear-marked and unspawned. Of the total number of dead salmon tallied, less than two-tenths of one per cent were bear-marked and not completely spawned.

These low figures can reasonably apply to only the lower one-half of the river as the fish caught at the weir were typical of only this part of the river. Above this, the bear activity was concentrated and a higher percentage of the salmon are believed to have been taken by these animals. On the basis of several assumptions, it was calculated that on the entire river system, 1,128 salmon or less than 1 per cent of the total escapement were taken by bear before spawning completely. This is in line with the figures obtained by Clark and should enforce his conclusions, although the latter figures from the present study have little accurate basis. In his study, Clark made many surveys of the dead salmon along the stream bank. It was expected that this would be possible here, but such was not the case. Clark dealt with an escapement of less than

11,000. The expected escapement here was 90,000 and the actual 136,390. The salmon numbers were too high to permit an accurate study such as was done by Clark and, even if the escapement had been no larger than 90,000, one man could not have done the work alone.

It is felt that this study might have produced the desired results if it had been done on a smaller stream with an escapement of under 25,000 pink salmon. Brown's River was too large, the escapement too high, and the stream too brushy for reasonably safe and practical work by one man. If a study on a stream of this size is done in the future, it is strongly recommended that a minimum of two men be assigned to it.

APPENDIX

1. Original and compiled data on file at Kodiak Field Station, Fish and Wildlife Service.

2. In order to abolish the unknown categories, the fish in these groupings were redistributed to the known categories.

In the following discussions the first letter represents the death category: N, Natural Death; B, Bear-Marked; S, Seal-Marked; and U, Unknown Death. The second letter(s) represent the sexual condition groups: S, Spawned; PS, Partially Spawned; US, Unspawned; and U, Unknown. The third letter represents the sex sub-groups: M, Male; F, Female; and U, Unknown. The letter X designates all categories, groups or sub-groups.

The first step was to obliterate the X, U,U, sections; the fish members in these sections were split and placed in the respective X,U,M, and F sections. This resulted in destroying the sex-unknown sections. The X,U,X, sections were then broken down and the fish members here placed, again on a percentage basis, in the X, spawning condition known, X sections. For example: numbers found in the B,U,M, section were

distributed to the B,S,M; B,PS,M; and B,US,M sub-group on basis of the percentages already in each section. This obliterated the sexual condition unknown groups.

The next step was to redistribute the numbers found in the unknown death category. This was done, again, on a percentage basis. An example should clarify this: the number found in the U,S,M subgroup was broken down and added to the numbers in the N,S,M; B,S,M; and S,S,M subgroups. The other subgroups included in the U,X,X category were similarly treated. This operation completed the obliteration of all the unknown headings.

Table 3 gives the totals of the various categories before any redistribution work was performed. Table 4 shows the simplified groupings after the above calculations were completed.

3. The following bird species were seen in the immediate vicinity of Brown's River from July 22 through September 22. The relative numbers are given as R, rara; C, common; and A, abundant. In certain cases an estimate of the numbers

in the area is given.

Species	Numbers	Abundance
Brandts Cormorant		C
Baird's Cormorant		C
Mallard	50	C
Green-winged Teal	15	C
American Goldeneye	15	C
Harlequin Duck	40	C
Red-Breasted Merganser	50	C
Bald Eagle	15	C
Sparrow Hawk		R
Wandering Tattler	6	C
Greater Yellowlegs		R
Sanderling		C
Parasitic Jaeger		R
Glaucous Gull	(500+)	A
Glaucous-winged Gull		C
Short-billed Gull	(300+)	A
Kittiwake		C
California Murre		C
Pigeon Guillimot	(30)	A
Belted Kingfisher		C

Species	Numbers	Abundance
Three-toed Woodpecker		R
American Magpie		C
Raven		A
Crow		R
Black-capped Chickadee		C
Water Ouzel		C
Winter Wren		C
Hermit Thrush		A
Alaska Yellow Warbler		R
Pileolated Warbler		C
Pine Grosbeak		C
Savannah Sparrow		A
Fox Sparrow		A

4. Scientific names were not used in the text in order to facilitate reading; only common names were mentioned. The scientific names are listed below for reference purposes.

Fish

Pink salmon	Oncorhynchus gorbuscha, Walbaum
Red salmon	Oncorhynchus nerka, Walbaum
Silver salmon	Oncorhynchus kisutch, Walbaum

Mammals

Harbor seal	Phoca r. richardii, Gray
Kodiak brown bear	Ursus middendorffi, Merriam
Kodiak Island weasel	Mustela kadiacensis, Merriam
Kodiak meadow mouse	Microtus kadiacensis, Merriam
Kodiak red fox	Vulpes harrimani, Merriam
Pacific otter	Lutra canadensis pacifica, Rhoades
Snowshoe hare	Lepus americanus macfarlani, Merriam
Stellar sea lion	Eumetopias jubata, Schreber

Plants

Bent-leaved Angelica	Angelica genuflexa
Sea-coast Angelica	Angelica lucida
Alaska Alder	Alnus fruticosa
Meadow Barley	Hordeum brachyantherum
Kenai Birch	Betula kenaica
Early Blueberry	Vaccinium ovalifolium
Bluegrass	Poa lanata (?)
Bluejoint	Calamagrostis canadensis
Black Cottonwood	Populus tricocarpa
Crowberry	Empetrum nigrum

Devil Club	*Echinopanax horridum*
Few-flowered Highbush Cranberry	*Viburnum edule*
Red-berried Elder	*Sambucus racemosa pubens*
Fireweed	*Epilobium augustifolium*
Common Horsetail	*Equisetum arvense*
Meadow Horsetail	*Equisetum pratense*
Western Water Hemlock	*Cicuta douglasii*
Nootka Lupine	*Lupinus nootkatensis*
Sea-Lyme-grass	*Elymus mollis*
Cow Parsnip	*Heracleum lanatum*
Salmonberry	*Rubus spectabilis*
Alaska Long-awned Sedge	*Carex macrochaeta*
Lyngbye's Sedge	*Carex lyngbyei*
Merten's Sedge	*Carex mertensii*
Clasping-leaved Twisted Stalk	*Streptopus amplexifolius*
Willow	*Salix ssp.*

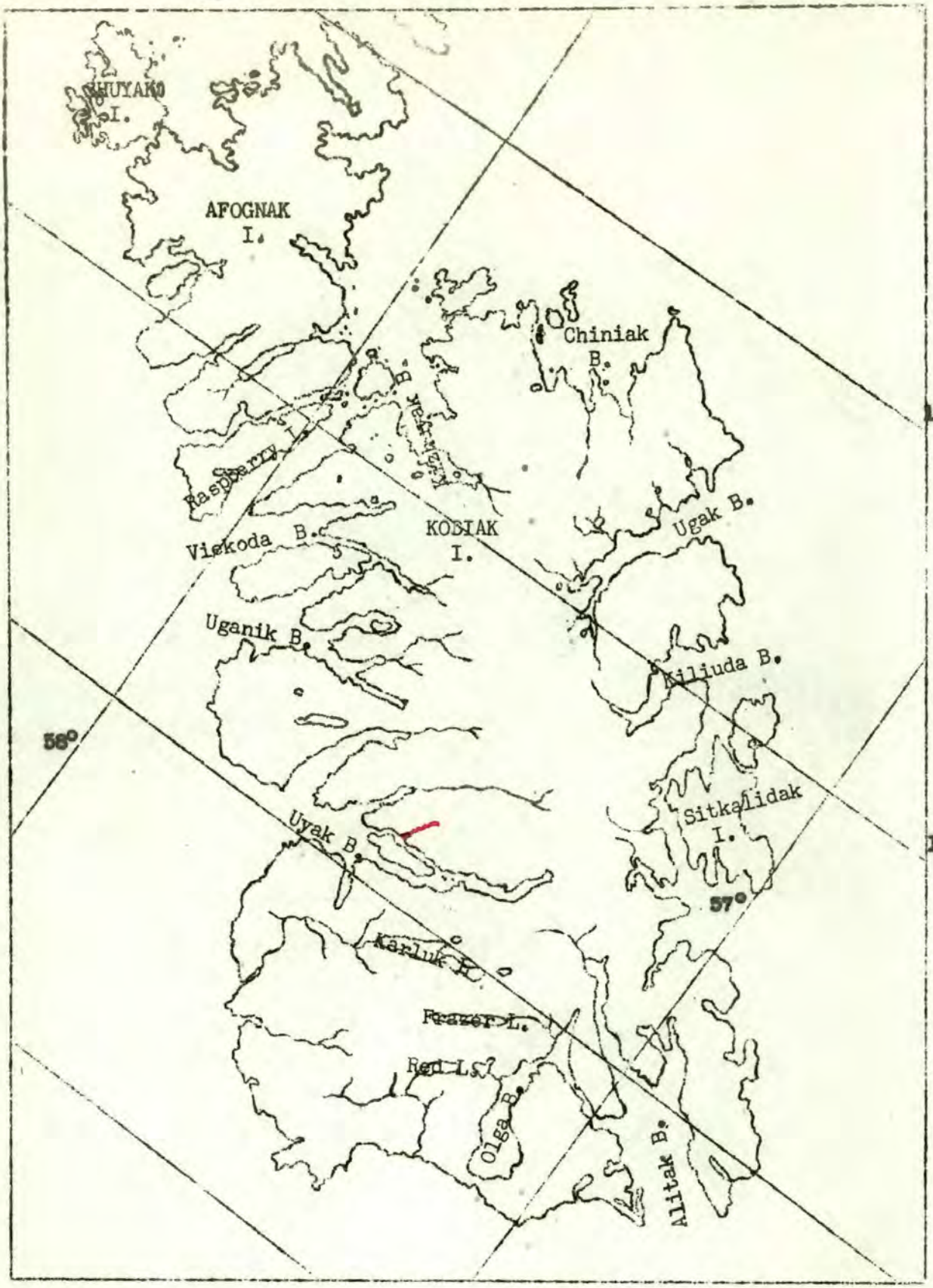

Figure 1. Map of Kodiak Island showing Brown's River (in red).

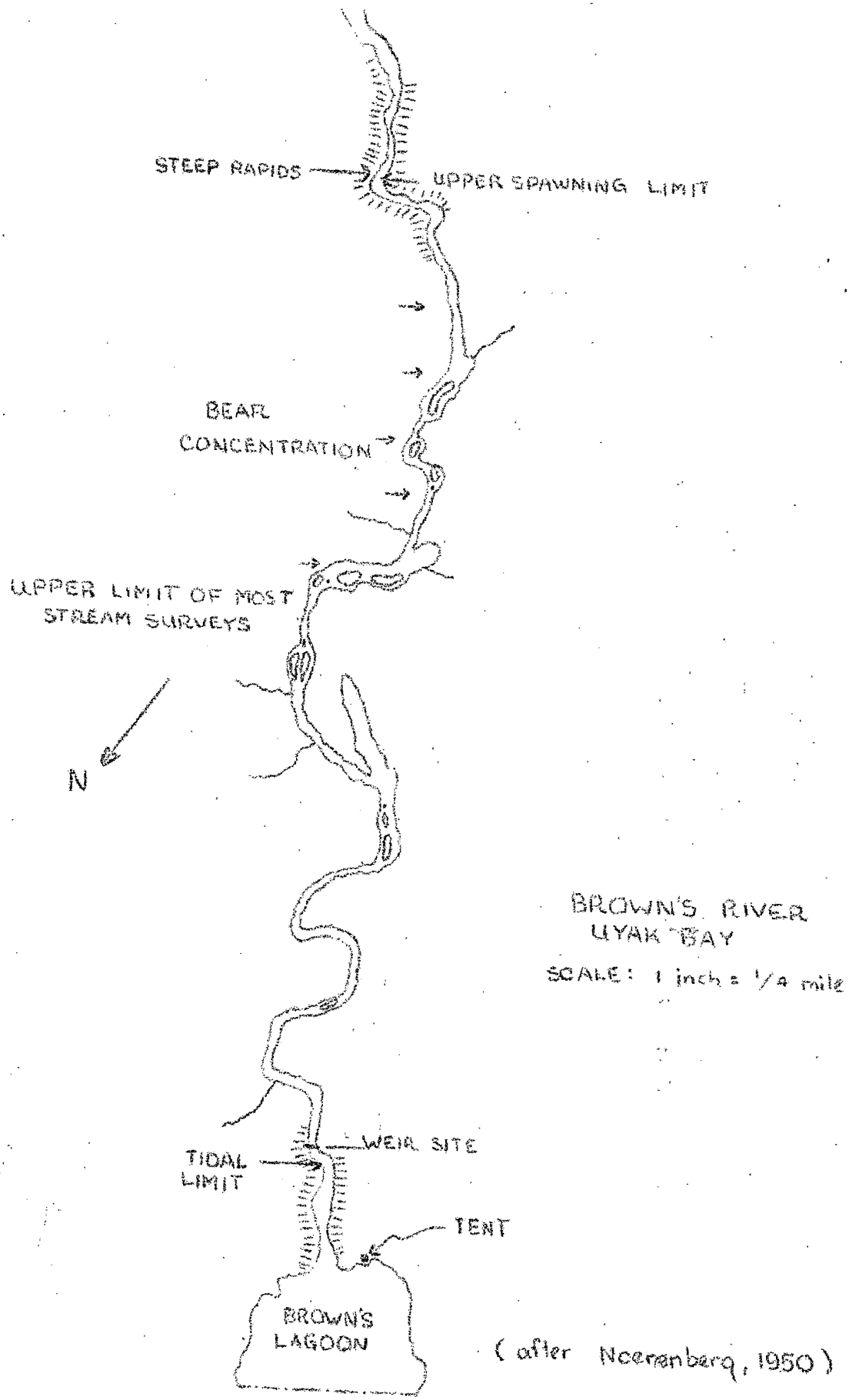

Figure 2.

(after Noerenberg, 1950)

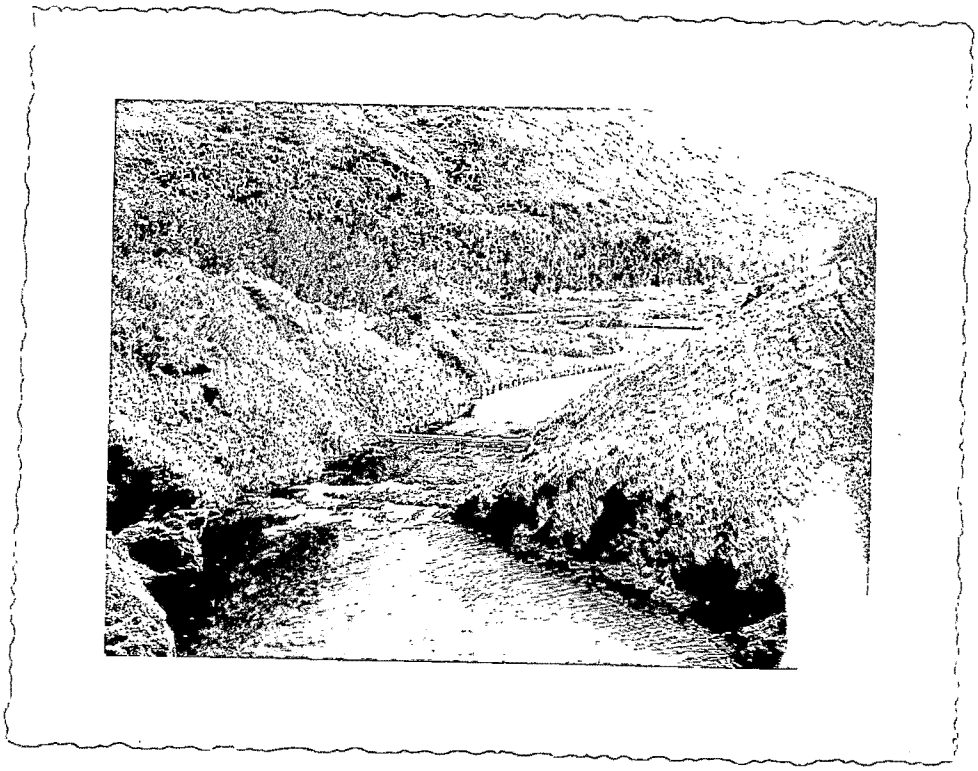

Figure 3. Brown's River showing weir site, relatively open lower portions, and falls series below weir site. (Photo by D. L. Spencer, FWS)

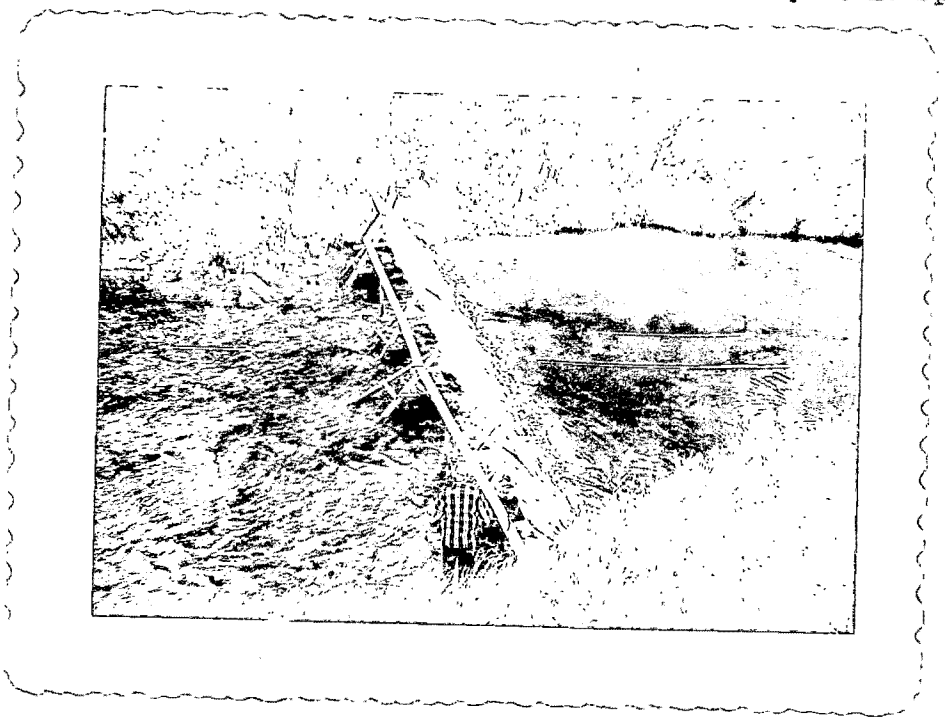

Figure 4. Weir showing dead fish on weir face and writer's wife, Ann.

Figure 5. Completed weir showing approximately 500 dead pink salmon.

Figure 6. Male pink salmon examples: Upper, spawned; lower, unspawned.

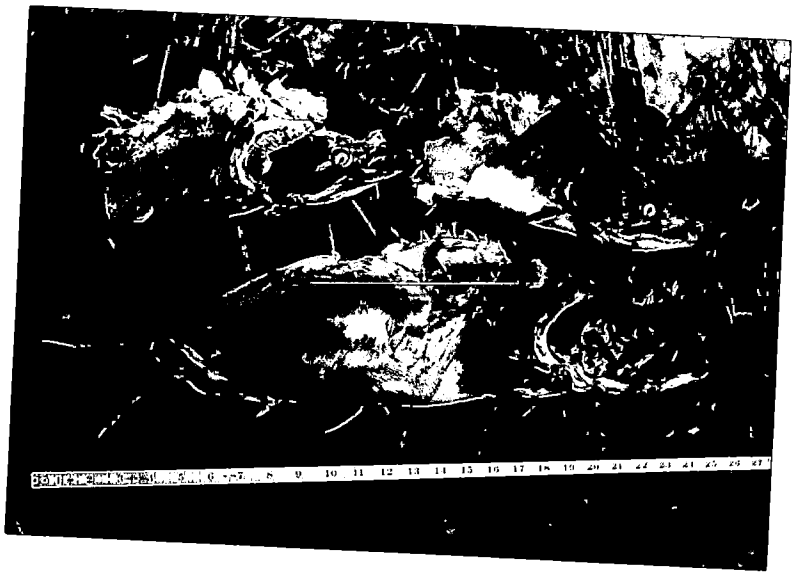

Figure 7. Typical bear-marked male pink salmon. Spotty appearance probably caused by fungus growths.

Figure 8. Male pink salmon showing variation in body form and length.

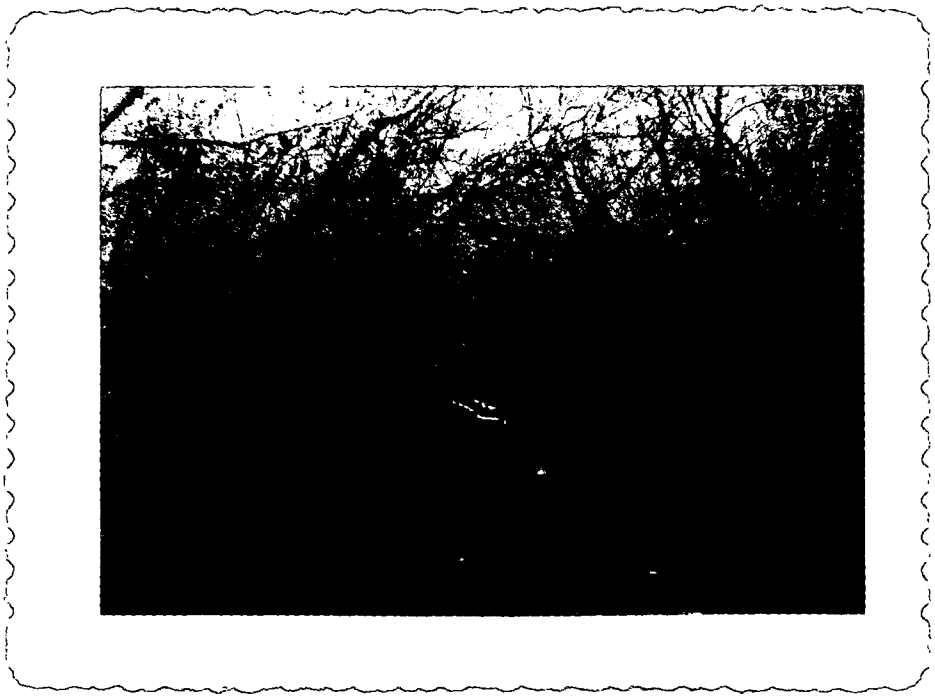

Figure 9. Old stream bed adjacent to present stream showing dense growth. Foreground, Boat-Operator Foster; background, Mr. Joe Maxwell.

Figure 10. Boat-Operator Foster, Mr. Joe Maxwell, and "Chiniak" standing on sand bar. Dense bank growth is typical of the upper portions of Brown's River.

Figure 11. Boat-Operator Foster along bank of Brown's River about 1/2 mile from river mouth.

Figure 12. Animal discovered living under tent platform at Brown's Lagoon.

Month	Inches*
January	5.38
February	6.26
March	2.57
April	4.67
May	5.94
June	4.72
July	3.74
August	2.87
September	7.44
October	7.25
November	7.03
December	7.26

* Data from United States Navy Weather Central, Kodiak, Alaska

Table 1. Mean yearly precipitation, Kodiak Island.

Date		Escapement	Estimate
July	22	5652	5348
	23	15669	
	24	13312	
	25	21968	
	26	14104	
	27	16715	
	28	10817	
	29	6949	
	30	5365	
	31	3748	
August	1	2246	
	2	1703	
	3	237	
	4	1582	
	5	1053	2000
	6	----	2000
	7	7753	1000
	8	487	500
	9	27	
	10	-4	

Date		Escapement	Estimate
August	21	70	
	22	53	
	23	340	
	242	373	
	25	193	
	26	344	
	27	479	
	28	59	100
	29	78	
	30	48	
	31	15	50
September	1	14	
	2	1	
	3	89	
	4	10	
		48	
	5	42	15
	6	20	
	7	11	
	8	10	
	9	7	

Table 2. Daily pink salmon escapement weir counts, Brown's River, 1952. (continued on next page)

Date		Escapement	Estimate	Date		Escapement	Estimate
August	11	-5		September	10	4	
	12	0			11	3	
	13	0			12	1	
	14	0			13	0	
	15	0			14	0	
	16	5			15	0	
	17	0			16	0	
	18	273			17	0	
	19	412			18	0	
	20	45			19	0	
					20	0	
					21	0	
					22	0	

Table 2. (continued)

	Spawned		Partially Spawned		Unspawned		Unknown		
	M	F	M	F	M	F	M	F	U
Natural Death	23875	3803	1060	713	444	1584	34	30	0
Bear-marked	489	72	30	3	3	7	32	28	3
Seal-marked	12	2	7	2	10	20	1	1	0
Unknown Death	108	35	6	6	8	23	239	156	197

Table 3. Totals of dead pink salmon tally categories.

	Spawned		Partially Spawned		Unspawned	
	Male	Female	Male	Female	Male	Female
Natural Death	24,323	3,980	1,083	745	476	1,697
Bear-Marked	529	102	33	4	3	10
Seal-Marked	13	2	7	2	12	22

Table 4. Dead pink salmon tallied at weir. (All unknowns obliterated)

Category	Group	Sub-group	Adjusted Totals	Percentage of Total				Percentage of Category		
				Category	Group	Sub-Group	Sex	Group	Sub-Group	Sex
Natural death	US	F	1,697	.9776	.0657	.0514	.2585	.0673	.0525	.2643
		M	476			.0144	.0179		.0147	.0184
	PS	F	745		.0553	.0225	.1135	.0566	.0231	.1160
		M	1,083			.0328	.0409		.0335	.0418
	S	F	3,980		.8566	.1204	.6063	.8761	.1232	.6179
		M	24,323			.7361	.9186		.7529	.9379
Totals			32,304					1.0000	.9999	.9982 .9981
Bear-marked	US	F	10	.0206	.0004	.0003	.0015	.0191	.0147	.0862
		M	3			.0001	.0001		.0044	.0053
	PS	F	4		.0011	.0001	.0006	.0543	.0059	.0345
		M	33			.0010	.0012		.0485	.0584
	S	F	102		.0191	.0031	.0155	.9266	.1498	.8793
		M	529			.0160	.0199		.7768	.9363
Totals			681					1.0000	1.0001	1.0000 1.0000
Seal-marked	US	F	22	.0018	.0010	.0007	.0033	.5862	.3793	.8462
		M	12			.0004	.0004		.2069	.3751
	PS	F	2		.0003	.0001	.0003	.1552	.0345	.0769
		M	7			.0002	.0002		.1207	.2187
	S	F	2		.0004	.0001	.0003		.0345	.0769
		M	13			.0004	.0005		.2241	.4062
Totals			58	1.0000	.9999	1.0001	.9998 .9997	1.0000	1.0000	1.0000 1.0000

Table 5. Percentage table of corrected data, weir-dead pink salmon.