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STATE OF IDAHO

Department of Fish and Game

SIS FRONT STREET BOISE, IDAHO

ROSS LEONARD
DIRECTOR

April 9, 1956

Reference is made to a copy of Supplement No. 2, "Analysis of Creel Census Data 1951-1954 of a Study of the Kokanee Fishery of Pend Oreille Lake, Idaho" by Willis H. Rich to the Corps of Engineers, U. S. Army. Although not a publication, this copy was sent to you to be added to the group of reports concerned with the Pend Oreille Lake fisheries study.

Since mailing it, the following errors have been brought to our attention and we are passing them along to you.

Page 3, Par. 1, Line 12 - "national" should be "rational"

Page 6, Table 2 - last heading item "100 f/t" should be "100 k/t"

Page 8, 9th line from bottom - delete "As noted above" and capitalize the "t" so the sentence will begin "The standard procedure" etc.

Page 8, 2nd and 3rd lines from bottom - change to read "10 Sundays, 10 Saturdays, and 30 week days..."

Yours very truly,

Ross Leonard, Director

Forrest R. Hauck

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Fisheries Research Supervisor

FRH:ls

1954-1955
Supplement No. 2: Analysis of Creel Census Data,
1951 through 1954

INTRODUCTION

The creel census was begun in 1951 and has been carried on chiefly by the Idaho Department of Fish and Game. The purpose was to develop information from which it would be possible to determine the "extent of any damage" to the fisheries of Pend Oreille Lake resulting from the construction and operation of the two dams. (Reference 2) The immediate objective was "to assemble a sample of catch records which could be used to estimate the magnitude of the fishing operations and the size of the catch removed from the lake." The census was carefully planned with due consideration for statistical standards and has been effectively conducted. During the first three years some changes were made in sampling methods; but, with appropriate adjustments, these will not affect the usefulness of the data. (Ref. 16) The methods used in the collection of data, in making adjustments, and in analysis have been adequately described and need not be reviewed here. (Refs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, and 13) The data have been presented in detail in reports issued by the Idaho Department of Fish and Game and form the basis for this study. (See especially Refs. 2, 7, 9, and 13.) The fishery for kokanee is of predominant importance in Pend Oreille Lake. Furthermore any adverse effect of the dams will probably result chiefly in a reduced abundance of these fish. For these reasons I have here considered only the data on the kokanee fishery.

In addition to presenting the creel census data, the Idaho Department has made various analyses of the data which were either issued separately or were included in the creel census reports. The Department engaged Dr. Daniel R. Embody as Consulting Statistician to aid in planning the census and to participate in the analysis of data. The analysis has proceeded primarily along the lines of Analysis of Variance and Multiple Correlation with the expressed purpose of making "estimates of the total annual catch of salmonids." (Ref. 11) From estimates of total catch and total number of hours fished, estimates have also been made of the average catch per fisherman per hour over the entire lake. (Refs. 6, 9, and 13)

The several agencies involved (Idaho Department of Fish and Game, U. S. Fish and Wildlife Service, Washington Water Power Company, and the Corps of Engineers, U. S. Army) have also cooperated in making surveys of the spawning grounds of the kokanee for the purpose of observing the numbers of fish spawning and the immediate effects of the conditions imposed by the dams on the survival of eggs and young fish. Various biological studies have also been made including the determination that the dominant age of the kokanee taken in the fishery is four years. The latter is important because it shows which brood-year is primarily responsible for the abundance of kokanee in any given fishing season and so makes it possible to relate abundance to conditions imposed by the dams. These are important phases of the over-all program of study but are not directly involved in this analysis of the creel census data. (Refs. 4, 5, 9, 10, 14, and 15)

In order to determine the effect on the fishery of the two dams it is obviously essential to have a reliable measure of the abundance of kokanee that are available to the fishermen from year to year. I question the value of estimates of total catch for this purpose no matter how refined they may be. Fishery biologists in general do not consider that total catches are good measures of abundance because they are affected so greatly by the amount of effort expended to produce the catch; and the amount of effort is affected by numerous causes, some of them economic while others are related to weather conditions. Total catch may be considered to be a measure of the amount of "utilization" of the fishery resources; but not a measure of abundance. Fishing effort is mentioned briefly in Reference 12 where it is stated that "a study of hours of effort and numbers of fishermen present on the stream throughout the season would reveal if the catch peak was related to effort..."; but, except for the estimates of average catch per hour mentioned above, no attempt has been made to relate effort to catch.

In general, fishery biologists use, as a measure of relative abundance, some "catch per unit of effort" such as the catch per fishing boat per day, catch per hundred hooks per set of long-lines, catch per fisherman per day, catch per fisherman per hour, etc. The average catchs of kokanee in Pend Oreille Lake per fisherman per hour (mentioned above) are of this nature; but these have been based on estimates of total numbers of fish caught and total numbers of hours fished over the entire lake. These estimates of totals combine heterogeneous data and a more reliable measure of catch per unit of effort can be had by using more homogeneous data, as I have attempted to do below.

It should be pointed out that such measures of relative abundance are actually measures of <u>apparent</u> relative abundance. Fishery biologists recognize that there are factors other than true abundance that may affect the catch per unit of effort. These are not well understood and are exceedingly difficult to demonstrate and measure; but they are associated with what has been called "availability." For example, if part, or all, of a population of fishes migrates, either horizontally or vertically, away from the waters customarily fished, the apparent abundance will be reduced even though the true abundance remains constant.

The creel census reports provide ample data from which estimates of relative abundance may be made. They are exceptional in that they show (a) the total number of fishermen engaged, (b) the total number of hours fished, (c) the total number of kokanee caught, and (d) the total number of fish caught for (1) each of the four localities (Hope, Sandpoint, Garfield, and Bayview), (2) each of the three types of fishermen (Resident, Non-resident, and Commercial), (3) each of the months during which the census was conducted (usually 10, February through November), and (4) each day of the census classified as to type of day (Sundays, Saturdays, and Weekdays) - 360 ultimate categories, approximately.

ultimate categories as a basis for determining an index of abundance for a given year; for example, the catch per fisherman per hour estimated for resident fishermen on Sundays in June at Bayview would provide an index that could be compared year by year. But this would be quite variable due to the inevitable "errors of random sampling" and would disregard a large part of the available data. The problem, therefore, is to select logical combinations of such ultimate categories that appear to be reasonably homogenous and that will give indices of satisfactory reliability. In discussing a similar problem Shewhart says "The engineer who is successful in dividing his data initially into rational subgroups based upon national hypotheses is...inherently better off in the long run than the one who is not thus successful." (W. A. Shewhart, "Economic Control of Quality of Manufactured Product", 1931, p. 299) And Grant states that "The basis of subgrouping calls for careful study, with a view to obtaining the maximum amount of useful information from any control chart." (Eugene L. Grant, "Statistical Quality Control," 1946, p. 181.) I have selected two such combinations which seem to provide good indices. These may not be the best possible combinations but they have been quite stable over the four base years, 1951 through 1954, during which abundance could not have been affected by the dams. The fundamental idea is to use the indices for these four base years as a "yard stick" with which to measure changes in abundance during the subsequent years in which the affect of the dams may be felt.

My approach to the problem has been a simple one statistically although it has involved considerable arithmetic. The plan has been to apply first principles of statistical analysis to the data for one year of the creel census to determine which categories may reasonably be combined to provide adequate indices of abundance; then to determine the same indices for the other base years. The mean of comparable indices for the base years may be taken as the best estimate of a measure of abundance previous to the installation of the dams. The variation of the indices for individual years around their mean will give a basis for determining "confidence limits" within which comparable measures, based upon the same conditions, may be expected to fall with a specified probability - say 19 times out of 20. Indices similarly calculated for years subsequent to the base years - years in which abundance may have been reduced by the presence of the dams - may then be compared with the standard established by the base years and it will be immediately apparent whether a statistically significant reduction in abundance has occurred. It is to be noted that creel census data are not yet available for any of the years except the base years. This is, I believe, a unique situation in fisheries research in that a standard has been established well before the figures are available that are to be compared with it. The Idaho Department of Fish and Game is to be commended for its foresight in establishing the creel census in time so that this could be done.

In the interest of conciseness, details of the study, especially those of a statistical nature, usually have been omitted.

As mentioned above, the first step has been to study in some detail the creel census data for one year in order to determine a combination of categories that would provide adequate indices of abundance. For various reasons I selected the creel census for 1954 as the one to be studied. This was the last year for which data were available, and was also the last one of the base years. The census for 1951 was not well stabilized, especially during the first few months, and some changes in methods for conducting the census were made in 1952 and 1953. The censuses for 1953 and 1954 were conducted without change and it is reasonable to assume that the procedures in 1954 were well established and will be followed in future years.

The data as published had been adjusted for "missed fishermen" - those known to have fished but who had not been interviewed by the census takers. The adjustment was made on a simple proportional basis and is described in Reference 2, pages 6, 7, and 8. Otherwise the data are those actually recorded in the field. For the purpose of calculating such an index of abundance as is suggested below this adjustment for missed fishermen is not necessary.

Two indices of relative abundance are possible - catch per fisherman per day and catch per fisherman per hour. Much of my preliminary work was done using catch per day, which is somewhat simpler to handle and is, as will be shown, almost as stable. However, since the Idaho Department has used catch per hour, it has seemed desirable to present both indices.

Retabulation. The pertinent data published in the creel census report for 1954 (Ref. 13) were retabulated in a condensed form that was more convenient for use in calculating statistics. Several different arrangements were tried but the one finally adopted is illustrated by Table 1, which gives the data for resident fishermen landing catches at Bayview during 1954. A total of 12 such tables was prepared, one for each type of fisherman at each locality. It does not seem necessary to reproduce all of these tables in this supplementary report because they are merely rearrangements of the data given in the original report; but copies are on file in the office of the District Engineer, Corps of Engineers, Seattle, Washington.

Each of these tables gives, for each type of day, the totals for each month of (1) number of fishermen (designated as "f"), number of hours fished ("h"), number of kokanee caught ("k"), and total number of fish caught ("t"). Then, for each ultimate category, defined by locality, type of fishermen, type of day, and month, the following statistics were calculated by slide rule and added to the table: (a) mean number of hours fished per fisherman ("h/f"), (b) mean catch of kokanee per fisherman per day ("k/f"), (c) mean catch of kokanee per fisherman per hour ("k/h"), and (d) percentage of kokanee in the total catch ("100k/t"). The first and fourth of these were useful in determining which categories might properly be combined, and the second and third are the indices of relative abundance. The first three

mean number of hours fished (h/f), mean number of kokanee caught per fisherman (k/f), mean number of kokanee caught per hour (k/h), and percentage of kokanee in total catch (100 k/t).)

Month	f	h	k	t	h/f	k/f	k/h	100 k/t
			Sundays					
Feb.	8	29	1	3	3.6	0.1	0.0 +	33
Mch.	150	832	785	793	5.5	5.2	0.9	99
Apr.	146	626	510	526	4.3	3.5	0.8	97
May	102	538	1806	1811	5.3	17.7	3.4	100-
June	260	1264	1053	1080	5.2	4.0	0.8	98
July	346	2224	7163	7177	6.4	20.8	3.2	100-
Aug.	99	525	360	383	5.3	3.6	0.7	94
Sept.	131	669	713	726	5.0	5.4	1.1	98
Oct.	81	381	872	883	4.7	10.8	2.3	100-
Nov.	0	0	0	0	—	—	—	—
Total	1323	7188	13263	13382	5.4	10.0	1.8	99
			Saturdays					
Feb.	216	985	477	537	4.6	2.2	0.5	89
Mch.	67	281	1242	1242	4.2	18.6	4.4	100
Apr.	35	150	215	215	4.3	6.2	1.4	100
May	70	390	751	758	5.6	10.7	1.9	99
June	222	1303	2734	2786	5.9	12.3	2.1	98
July	239	1402	3813	3833	5.9	16.0	2.7	100-
Aug.	69	312	350	359	4.5	5.1	1.1	98
Sept.	106	510	728	737	4.8	6.9	1.4	99
Oct.	23	111	320	322	4.8	13.9	2.9	99
Nov.	6	30	12	12	5.0	2.0	0.4	100
Total	1053	5474	10642	10801	5.2	10.1	2.0	99-
			Weekdays					
Feb.	67	238	134	138	3.6	2.0	0.6	97
Mch.	92	427	1569	1572	4.6	17.1	3.7	100-
Apr.	116	527	1172	1174	4.5	10.1	2.2	100-
May	299	1775	4929	4960	5.9	16.2	2.7	98
June	328	2033	4313	4440	6.2	13.2	2.1	97
July	182	982	972	1082	5.4	5.4	1.0	90
Aug.	81	435	417	430	5.4	5.2	1.0	97
Sept.	241	1255	1613	1633	5.2	6.7	1.3	99
Oct.	42	170	511	511	4.0	12.2	3.0	100
Nov.	11	43	140	141	3.9	12.7	3.3	99
Total	1459	7885	15770	16081	5.4	10.8	2.0	98
			Totals by Months					
Feb.	291	1252	612	678	4.3	2.1	0.5	90
Mch.	309	1540	3596	3607	5.0	11.6	2.3	100-
Apr.	297	1303	1897	1915	4.4	6.4	1.5	99
May	471	2703	7486	7529	5.7	15.9	2.8	99
June	810	4700	8100	8306	5.8	10.0	1.7	97
July	767	4608	11948	12092	6.0	15.6	2.6	99
Aug.	249	1272	1127	1172	5.1	4.5	0.9	96
Sept.	478	2434	3054	3096	5.1	6.4	1.3	99
Oct.	146	662	1703	1716	4.5	11.7	2.6	99

unit.

Next the columns in each sub-table, defined by locality, type of fisherman, and type of day, were summated to give totals for the year and weighted statistics for the year were calculated and added to the sub-tables (lines designated "Totals" at the bottom of each sub-table).

Finally, a fourth sub-table was prepared, defined by locality and type of fishermen, showing, for each month, the totals of the three types of days and the corresponding weighted statistics. The first four columns of this sub-table were summated to give the totals for the entire year for the designated locality and type of fishermen and from these totals weighted statistics for the year were calculated. The data and statistics for the entire year appear, therefore, in the bottom line of each table defined by locality and type of fishermen. (See table 1.)

In order to eliminate inaccuracies in transcribing data and calculating statistics, two entirely independent series of these tables were prepared. Few significant errors had been made in the first series and these were corrected. Slight differences in the values of the statistics were ignored - those of the order of 0.1 or 1%. These were due chiefly to differences in rounding off or in reading the slide rule.

These 12 tables were then studied to determine what combinations of data would provide satisfactorily stable indices of relative abundance. The data for each fundamental category (type of fishermen, locality, type of day, and month) were compared and, in each case, only those elements were combined as a basis for calculating indices that were reasonably homogeneous.

Type of fishermen. It is common knowledge that the commercial fishery is quite different from the sport fishery that is carried on by both resident and non-resident fishermen. This is clearly shown by the statistics given in Table 2. The commercial fishermen fish more hours per day, catch approximately ten times as many kokanee per day or per hour, and their total catch consists almost entirely of kokanee while the sport fishermen catch appreciable percentages of other fish. Another point of difference between the commercial and the sport fisheries is the fact that the commercial fishery is largely confined to the first half of the year (February through June) while the sport fishery covers the months from February through November. These differences make it illogical to combine the data on commercial and sport fisheries: to do so would increase the variability (variance) of the derived statistics so that much larger deviations from the means of the base years would be necessary before statistically significant differences could be claimed. I have, therefore, calculated separate indices for the commercial and sport fisheries.

On the other hand, there is comparatively little difference in the statistics for resident and non-resident fishermen so that these may reasonably be combined to give indices for the sport fishery.

Statistics for 1954 for each type of fishermen and each locality

Type of fishermen	Locality	Statistic h/f	k/f	k/h	100f/t
Resident	Hope	4.2	6.5	1.6	90
	Sandpoint	3.1	2.4	0.8	31
	Garfield	5.0	8.5	1.7	94
	Bayview	5.4	10.4	1.9	98
Non-resident	Hope	4.6	4.7	1.0	94
	Sandpoint	4.4	4.4	1.0	78
	Garfield	5.3	5.7	1.1	94
	Bayview	5.6	10.3	1.9	98
Commercial	Hope	6.4	100.2	15.8	100
	Sandpoint	6.2	81.0	13.2	99
	Garfield	5.7	60.4	10.6	100
	Bayview	6.0	53.2	9.0	100

Locality. From Table 2 it is apparent that there are locality differences in the statistics for each type of fishermen. The statistics for Sandpoint are especially divergent. The sport fishermen of both types at this locality fish fewer hours per day, catch much larger percentages of fish other than kokanee, and the indices of relative abundance (k/f and k/h) are, with one exception, lower than those at any other locality. The exception is for the indices k/h for non-resident fishermen which is the same (to the nearest tenth) as that at Hope. These differences are so great that it has seemed best to eliminate the data from Sandpoint altogether and to calculate the indices for the sport fishery from the data for the other three localities. This, however, takes out, for 1954, less than 5% of the total sport catch recorded in the census, as shown in Table 3.

Table 3
Kokanee reported in the census for 1954
by type of fishermen and locality

Locality	Sport Fishery Resident	Non-resident	Total	Commercial Fishery	Grand Total
Hope	5840	3324	9164	12426	21590
Sandpoint	4027	1162	5189	12031	17220
Garfield	7895	6950	14845	26638	41483
Bayview	39675	56163	95838	28818	124656
Totals	57437	67599	125036	79913	204949

resident and non-resident fishermen. There is a marked tendency for all of the statistics for both types of sport fishermen to increase as one passes from Sandpoint through Hope and Garfield to Bayview; i.e., from the lower to the upper end of the lake. In spite of these locality differences, I have decided, rather arbitrarily, to combine the data for the sport fisheries at Hope, Garfield, and Bayview in order to get annual indices for the sport fishery as a whole. This will not disturb the stability of the annual indices unless marked changes take place in the proportions of recorded catches in the different localities. Individual locality indices, such as those given in Table 2, might be used but I have not attempted to do this.

Locality differences for the commercial fishery are quite different from those of the sport fishery. There are relatively slight differences in number of hours fished and percentage of kokanee in the total catch; but there are distinct differences in the indices of relative abundance. These show a well marked trend from the lower to the upper end of the lake; but this is the reverse of the trend shown by the sport fishery: i.e., the highest values are at the lower end of the lake and the lowest at the upper end. I can offer no explanation for this peculiarity but it would seem to rule out the interpretation that there is a trend in abundance from one end of the lake to the other. It may be that the more efficient sport fishermen tend to land their catches at Garfield and Bayview while the more efficient commercial fishermen tend to land their catches at Sandpoint and Hope. However, my knowledge of local conditions is not sufficient to warrant offering this as more than a tentative suggestion. Again I have decided to combine the data from all four localities as a basis for calculating annual indices for the commercial fishery as a whole. The individual locality indices for commercial fishermen are given in Table 2.

Type of day. A study was made of the variability of indices for different types of days within a single important category defined by locality and type of fishermen. The category selected was that of resident fishermen at Bayview. The monthly indices are shown in Tables 4A and 4B and the annual indices (unweighted mean of the monthly indices) are given in the bottom lines of each of these tables.

Monthly indices for Bayview
Resident fishermen by days,
1954

A. Index k/f
Day

Month	Sundays	Saturdays	Weekdays	Mean (unweighted)
Feb.	0.1	2.2	2.0	1.4
Mch.	5.2	18.6	17.1	13.6
Apr.	3.5	6.2	10.1	6.6
May	17.7	10.7	16.2	14.9
June	4.0	12.3	13.2	9.8
July	20.8	16.0	5.4	14.1
Aug.	3.6	5.1	5.2	4.6
Sept.	5.4	6.9	6.7	6.3
Oct.	10.8	13.9	12.2	12.3
Nov.	---	2.0	12.7	7.3
Mean (unweighted)	7.9	9.4	10.1	9.1

B. Index k/h

Feb.	0.0	0.5	0.5	0.3
Mch.	0.9	4.4	3.7	3.0
Apr.	0.8	1.4	2.2	1.5
May	3.4	1.9	2.7	2.7
June	0.8	2.1	2.1	1.7
July	3.2	2.7	1.0	2.3
Aug.	0.7	1.1	1.0	0.9
Sept.	1.1	1.4	1.3	1.3
Oct.	2.3	2.9	3.0	2.7
Nov.	---	0.4	3.3	1.8
Mean (unweighted)	1.5	1.9	2.1	1.8

As noted above, the standard procedure of the creel census provides for observations at each locality on one Sunday, one Saturday, and three week-days each month. The monthly statistics for Sundays and Saturdays are therefore, for each locality, generally the observation for a single day. The data for the three week days have been combined so that the monthly statistics for week days are the weighted means for three days. Similarly, the annual statistics for each locality consist of the means of about 10 Saturdays, and 30 week days, since the census has ordinarily covered the ten months from February through November.

for types of days. This indicates that the data for the three types of days may be combined to provide a single value for each month. (The same tables are used in the next section to determine the statistical significance of the differences in monthly indices in which the three types of days are combined.) A similar study might be made of the other categories defined by locality and type of fishermen, but I have not attempted to do this because of limited time.

The annual statistics for the different types of days are given in Table 5 for all localities and types of fishermen.

Table 5.

Indices for 1954 by locality, type of fishermen, and type of day (weighted means)

Locality	Type of fishermen	Type of day	h/f	k/f	k/h
Hope	Res.	Su.	4.4	4.2	1.0
		Sa.	4.2	3.7	0.9
		Wk.	4.0	10.0	2.5
	N-Res.	Su.	4.9	3.9	0.8
		Sa.	4.8	4.9	1.0
		Wk.	4.2	5.4	1.3
	Com.	Su.	4.4	33.2	7.6
		Sa.	5.8	25.0	4.3
		Wk.	6.6	118.0	17.8
Sandpoint	Res.	Su.	3.6	4.9	1.4
		Sa.	3.2	1.9	0.6
		Wk.	2.8	0.8	0.3
	N-Res.	Su.	4.3	7.5	1.8
		Sa.	4.6	2.5	0.6
		Wk.	4.2	3.3	0.8
	Com.	Su.	6.1	70.5	11.5
		Sa.	6.4	100.2	15.8
		Wk.	6.1	75.0	12.3
Garfield	Res.	Su.	5.1	7.8	1.5
		Sa.	4.9	8.0	1.6
		Wk.	5.0	10.1	2.0
	N-Res.	Su.	5.4	5.0	0.9
		Sa.	5.8	6.1	1.2
		Wk.	4.9	5.6	1.1
	Com.	Su.	6.0	38.4	6.4
		Sa.	5.5	67.2	12.2
		Wk.	5.7	67.5	11.8
Bayview	Res.	Su.	5.4	10.0	1.8
		Sa.	5.2	10.1	2.0
		Wk.	5.4	10.8	2.0
	N-Res.	Su.	5.5	9.6	1.7
		Sa.	5.8	12.2	2.2
		Wk.	5.4	10.2	1.9

combined.

The statistics for the commercial fishery are more variable. They are much higher than those for the sport fishery but are of the same order of magnitude at all localities. As mentioned above I have used the data for all four localities in calculating indices for the commercial fishery. At Hope and Bayview the indices are notably higher on weekdays than on Sundays and Saturdays. At Garfield there is no appreciable difference between the indices for Saturdays and weekdays but both are approximately twice those for Sundays. At Sandpoint the figures for Sundays and weekdays are similar but those for Saturdays are somewhat higher. The generally better success of the commercial fishermen on weekdays may be due to the fact that there are relatively fewer sport fishermen during these days; or it may indicate that only the more adept commercial fishermen fish on weekdays. Separate annual indices might be calculated for each type of day and those for different years compared. However, since the data for each month at each locality are uniform with respect to the number of days of each type on which observations are made, the different types of days may be combined and still provide comparable monthly and annual indices for the commercial fishery.

Months. The monthly indices for the sport fishery within categories defined by locality and type of fishermen are extremely variable. This is illustrated, for resident fishermen at Bayview, by the columns headed by k/f and k/h in the last section of Table 1 in which the index k/f varies from 2.1 to 15.9 and the index k/h varies from 0.5 to 2.8. The analysis of variance of the data in Tables 4A and 4B (above) showed that the differences in monthly indices were significant at, approximately, the .05 level. Similar variability is apparent in all other comparable categories; but these have not been tested for significance. It is also apparent in Table 6 which gives the monthly data and statistics for the entire sport fishery - exclusive of Sandpoint.

Table 6.

Monthly data and statistics for the sport fishery, 1954. (Combines data on resident and non-resident fishermen at Hope, Garfield and Bayview.

Month	f	h	k	h/f	k/f	k/h
Feb.	329	1403	656	4.3	2.0	0.5
Mch.	430	2078	4589	4.8	10.7	2.2
Apr.	515	2289	3975	4.4	7.7	1.7
May	1798	9126	22140	5.1	12.3	2.4
June	2682	15138	23879	5.6	8.9	1.6
July	2672	15389	33778	5.8	12.6	2.2
Aug.	1287	6298	6236	4.9	4.8	1.0
Sept.	2193	11481	16200	5.2	7.4	1.4
Oct.	751	3707	8141	4.9	10.8	2.2
Nov.	369	1946	253	5.3	0.7	0.1
Total	13026	68855	119847	5.3	9.2	1.7

It will be noted that the indices for February and November are exceptionally low.

sport fishing in February and November, and, as mentioned above, the 1954 indices for these months are much lower than those for the other months. More important is the fact that data for all three of these months are not available for all of the base years. In 1951 the organization of the creel census was not finally standardized until in June although "the first organization ... was drawn up during the week of March 10." (Ref. 2.) The procedure during April and May was not quite the same as that in later months, but it was near enough so that the data reasonably can be included. In 1952 the census did not start until April 1. In both 1951 and 1952 the census was stopped at the end of October. All three months were included in the censuses of 1953 and 1954. In calculating annual indices for the base years it seems desirable to use the same categories for each year - and, of course, for the subsequent years. For these reasons they have been based on the data for the months April through October only. Uniformly determined annual indices are virtually a necessity for the purpose of comparing abundance in the base years with that in the subsequent years that may be affected by the dams.

Table 7.

Monthly data and statistics for the commercial fishery, 1954.
(Combines data in all localities.)

Month	f	h	k	h/f	k/f	k/h
Feb.	126	662	1068	5.2	8.5	1.6
Mch.	214	1222	10260	5.7	48.0	8.4
Apr.	374	2257	23226	6.0	60.5	10.3
May	290	1710	29816	5.9	103.0	17.5
June	148	951	10115	6.4	68.4	10.6
July	67	429	3393	6.4	50.6	7.9
Aug.	23	128	1504	5.6	65.5	11.8
Sept.	14	86	531	6.1	38.0	6.2
Total	1256	7445	79913	5.9	63.8	10.7

The data for the commercial fishery of 1954 are given in Table 7. While some commercial fishing was carried on in all months from February through September, it is obvious that most of it was limited to the months March through June. The same was true of the commercial fishery for 1953. There are, however, only three months that are represented in all four of the base years. There are no data for March, 1952 and, for reasons given above, those for 1951 cannot be considered strictly comparable with those obtained after the census methods were standardized. I have decided, therefore, to base the annual indices for the commercial fishery on the data for April, May, and June only.

the sums of the data (f, h, and k) for both resident and non-resident fishermen for the months April through October; and for the commercial fishery for the sums of the data for all localities for the months April through June. There are, therefore, four indices each of which can be used to show variations in relative abundance from year to year.

Each of these annual indices is a weighted mean of the monthly indices. Unweighted means might have been used but weighted means are the more stable. Incidentally, the weighted means will be larger or smaller than the unweighted means depending upon whether the weights and monthly indices are, respectively, positively or negatively correlated; but this is not important to the present purposes. Discrepancies between weighted and unweighted means due to this will be noted in the tables; as, for example, the annual means given in Table 1 and Table 4. The weighted means are consistently larger than the corresponding unweighted means. This indicates that, as would be expected, there is more fishing when the fishing is better.

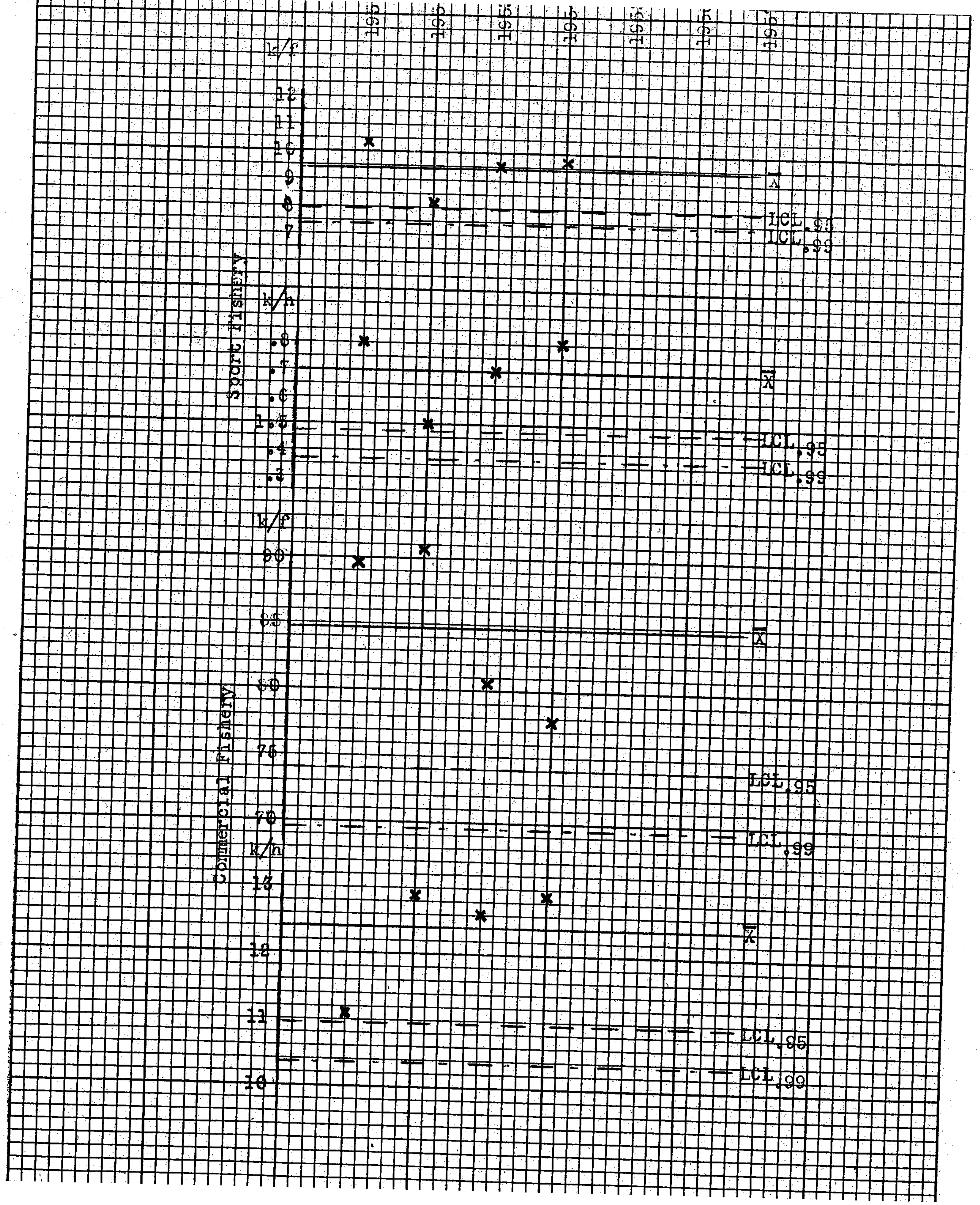
The two indices, k/f and k/h are highly correlated. This would be expected from the fact that the average number of hours of fishing is fairly constant. The bivariate distribution is, however, strongly heteroscadistic - i.e., the absolute variability of each variate increases proportionately as the variate increases. In such distributions the usual Pearsonian Coefficient of Correlation (r) cannot be used to measure correlation. However, a related measure of correlation can be calculated from the logarithms of the original values although it is difficult to interpret. This has been done for one series of indices - k/f and k/h for the months April through October and for sport fishermen at Garfield and Bayview combined. The correlation between the logarithms was positive and the coefficient was over .98 which is exceedingly high. Obviously these indices are not independent and either may be used as a measure of abundance.

INDICES OF RELATIVE ABUNDANCE FOR THE FOUR BASE YEARS

The four indices as described have been determined for each of the four base years and are given in Table 8.

Table 8. Indices of relative abundance for the four base years, 1951 - 1954

	Sport fishery		Commercial fishery	
Year	k/f	k/h	k/f	k/h
1951	10.3	1.8	89.6	11.1
1952	8.2	1.5	90.8	12.9
1953	9.5	1.7	80.5	12.6
1954	9.6	1.8	77.8	12.9
Unweighted mean, $\bar{X}$	9.4	1.7	84.7	12.4
s	0.876	0.141	6.493	0.862
C.V.	9.3	8.3	7.7	7.0
$LCL_{.95}$	7.959	1.468	73.994	10.957
$LCL_{.99}$	7.362	1.372	69.566	10.369



Sport Fishery
k/f
12
11
10
9
8
7
LCL.95
LCL.99
k/h
.8
.7
.6
.5
.4
.3
LCL.95
LCL.99
Commercial Fishery
k/f
90
85
80
75
70
LCL.95
LCL.99
k/h
13
12
11
10
LCL.95
LCL.99

include the data for all months while those in Table 8 include only the data for the months April through October.) Below the body of the table are given, for each index; (1) the unweighted means ($\overline{X}$); (2) the Standard Deviations (s); (3) the Coefficients of Variation (C.V.); and (4) two Confidence Limits for each index ($LCL_{.95}$ and $LCL_{.99}$). The means and standard deviations need no explanation.

The Coefficient of Variation is a pure number which expresses the standard deviation as a percentage of the mean. It is a measure of relative variability. Coefficients of Variation may, therefore, be directly compared. It is apparent that the relative variability of all four of the indices is about the same; and the coefficients are relatively low, indicating that the values of each index are relatively stable over the four base years. The largest coefficient is 9.3 and the smallest 7.0. Even this extreme difference is not significant statistically - it would occur by chance a little more than half the time. In respect of variability, therefore, the four indices are substantially equal.

It is interesting to note in this connection that the Coefficient of Variation of the catch per hour of all fishermen as calculated by the Idaho Fish and Game Department from estimates of the total catch and total number of hours fished (Ref. 17) is much more variable than the indices given here. The Coefficient of Variability is 23.6. This index would, obviously, provide a much less critical method for demonstrating reduced abundance.

The confidence limits have been so calculated as to show the value of the index above which 95 and 99 percent of values would be expected to fall solely as a result of "the errors of random sampling." From the opposite point of view, only 5 percent and 1 percent of the comparable values will fall below the respective confidence limits solely by chance. The symbol for these confidence limits, LCL, is adapted from the control chart technique and signifies the "Lower Control Limit."

Typical control charts for the four indices are presented in Figure 1. These are extended beyond the base years so that new points, calculated in the same manner as these for the base years, can be added as they become available. If a point falls below one of the lower control limits it will indicate, with the specified probability, that a real reduction in abundance has occurred. For example, if the value of k/f for the sport fishery in 1955 should prove to be 7.5 one may conclude that abundance is lower than that of the base years with a probability of less than .05(one chance in 20) of being wrong. Or, if it should drop to 7.0, the chance of being wrong in reaching this conclusion would be less than one in 100. It goes without saying that the evidence for or against a real change in abundance will be strengthened as years are added to the series.

/s/ Willis H. Rich
/t/ Willis H. Rich

2120 Santa Cruz Avenue
Menlo Park, California
8 February 1956

(Arranged approximately in the order in which issued)

1. Instructions for Creel Census at Lake Pend Oreille. (June, 1951?)
Wm. Markham Morton and Timothy M. Vaughan
(Issued by either the Idaho Department of Fish and Game or the U.S. Fish and Wildlife Service. Not dated but it is stated in Reference (2) that these instruction were "written in June.")

2. Pend Oreille Lake Census 1951: Tabulation of Census Data by Days. (November 29, 1951)
Daniel R. Embody
Research Report, Idaho Department of Fish and Game

3. Lake Pend Oreille Creel Census 1951: Tabulation of Census Data by Months. (February 5, 1952)
Daniel R. Embody
Research Report, Idaho Department of Fish and Game

4. Fisheries Investigations of Lake Pend Oreille, Idaho, 1951: Biological and Economic Survey. (December 12, 1952)
Paul Jeppson and Tim Vaughan
Completion Report; Investigations Projects, Idaho Department of Fish and Game.

5. Fish and Wildlife Resources Affected by Albeni Falls Project, Pend Oreille River, Idaho. (March, 1953)
James T. McBroom
Interim Report, U. S. Fish and Wildlife Service

6. Creel Census - Pend Oreille Lake. (October, 1953)
Paul Jeppson
Completion Report, Investigations Projects, Idaho Department of Fish and Game.

7. Pend Oreille Lake Census, 1952: Tabulation of Census Data by Days (April 1, 1953)
Daniel R. Embody
Reaearch Report, Idaho Department of Fish and Game
(Issued as an appendix to Reference 6.)

8. Biological and Economic Survey of Fishery Resources in Lake Pend Oreille. (Undated but probably late in 1953)
Forrest R. Hauck
Progress Report, Idaho Department of Fish and Game

9. Lake Pend Oreille Creel Census (for 1953). (February, 1954)
Paul Jeppson
Completion Report, Idaho Department of Fish and Game
(Appendix A gives Creel Census Data by Days.)

10. The Probable Effect of Albeni Falls Dam on the Kokanee Fishery of Lake Pend Oreille, Idaho. (February, 1954)
Willis H. Rich
Corps of Engineers, Department of the Army, Seattle District

11. Biological and Economic Survey of Fishery Resources in Lake Pend Oreille: A Comparison of the Total Catches for the years 1951 and 1952. (February 13, 1954)
Daniel R. Embody
Job Completion Report, Idaho Department of Fish and Game

12. Analysis of Variance Calculations as Applied to Creel Census Data. (June 2, 1954)
Daniel R. Embody
Research Report, Little Salmon River Project, Idaho Department of Fish and Game

13. Lake Pend Oreille Creel Census, 1954. (February, 1955)
Charles R. Whitt
Job Completion Report, Idaho Department of Fish and Game

14. Study of the Kokanee Fishery of Pend Oreille Lake, Idaho, 1954-1955 (April, 1955)
Willis H. Rich
Corps of Engineers, U. S. Army, Seattle District

15. Same: Supplement No. 1: Scale Studies. (July 9, 1955)
(The present report is Supplement No. 2.)

16. Statistical Adjustments of Creel Census Data for Pend Oreille Lake to Compensate for Changes in Census Methods. (June 15, 1955)
Daniel R. Embody
Research Report, Idaho Department of Fish and Game

17. Lake Pend Oreille Creel Census 1951-1955 (No date)
Idaho Department of Fish and Game
(This is a series of three tables presented to the Pend Oreille Technical Committee on November 3, 1955. They compare the data for the base years 1951 through 1954 with the data for February through August, 1955 and with predictions of the total catch for 1955.)