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By:

Asa T. Wright
Division of Commercial Fisheries
Juneau, Alaska

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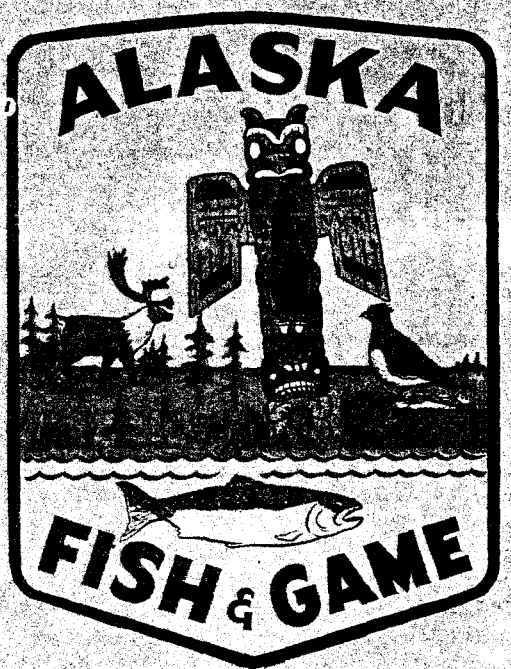

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THE USE OF SCALE CIRCULI SPACING AS A MEANS OF SEPARATING RACES OF PRINCE WILLIAM SOUND PINK SALMON

by

Asa T. Wright, Fishery Biologist[1/]
Alaska Department of Fish and Game
Division of Commercial Fisheries
Juneau, Alaska

INTRODUCTION

Biologists have recently shown that a difference existed in the spacing of the scale circuli laid down in the first year of ocean growth for pink salmon from different areas along the Pacific coast (Amos, 1960 and Pearson, 1963). As a result of this finding, several methods of measurement, using the average distance between scale circuli of the first growing season, were investigated for their ability to separate different segments of the Prince William Sound pink salmon run during the years 1963 and 1964.

METHODS

Two samples of scales were used for the study. One sample consisted of pink salmon scales collected in 1964 off purse seine caught fish delivered to Japanese packers and the other set was collected in 1963 off both purse seine and beach seine caught fish. The areas and dates represented in the 1964 sample are Montague Island (Alaska Department of Fish and Game Statistical Area 227-10), 7/30/64 and Port Nellie Juan (ADF&G Statistical Area 224-40), 7/25/64. Those in the 1963 sample are Sheep Bay (ADF&G Statistical Area 221-20), 6/19/63; Port Gravina (ADF&G Statistical Area 221-30), 6/25/63; and Point Elrington to Chenega Island (ADF&G Statistical Areas 226-20, 40 and 50), 7/30/63 (see Figure 1).

In the field, the scales were removed from the fish from an area below the dorsal fin at about the level of the lateral line and placed on numbered gummed cards. Plastic impressions of the scales were made in the laboratory using a hot press and 6,000 to 7,000 pounds pressure for 10 minutes (Clutter and Whitesel, 1956). The scale impressions were read at 80X magnification on an Eberbach microprojector scale reader, with all measurements being made in millimeters (Lagler, 1956).

1/ Mr. Wright is no longer employed by the Alaska Department of Fish and Game.

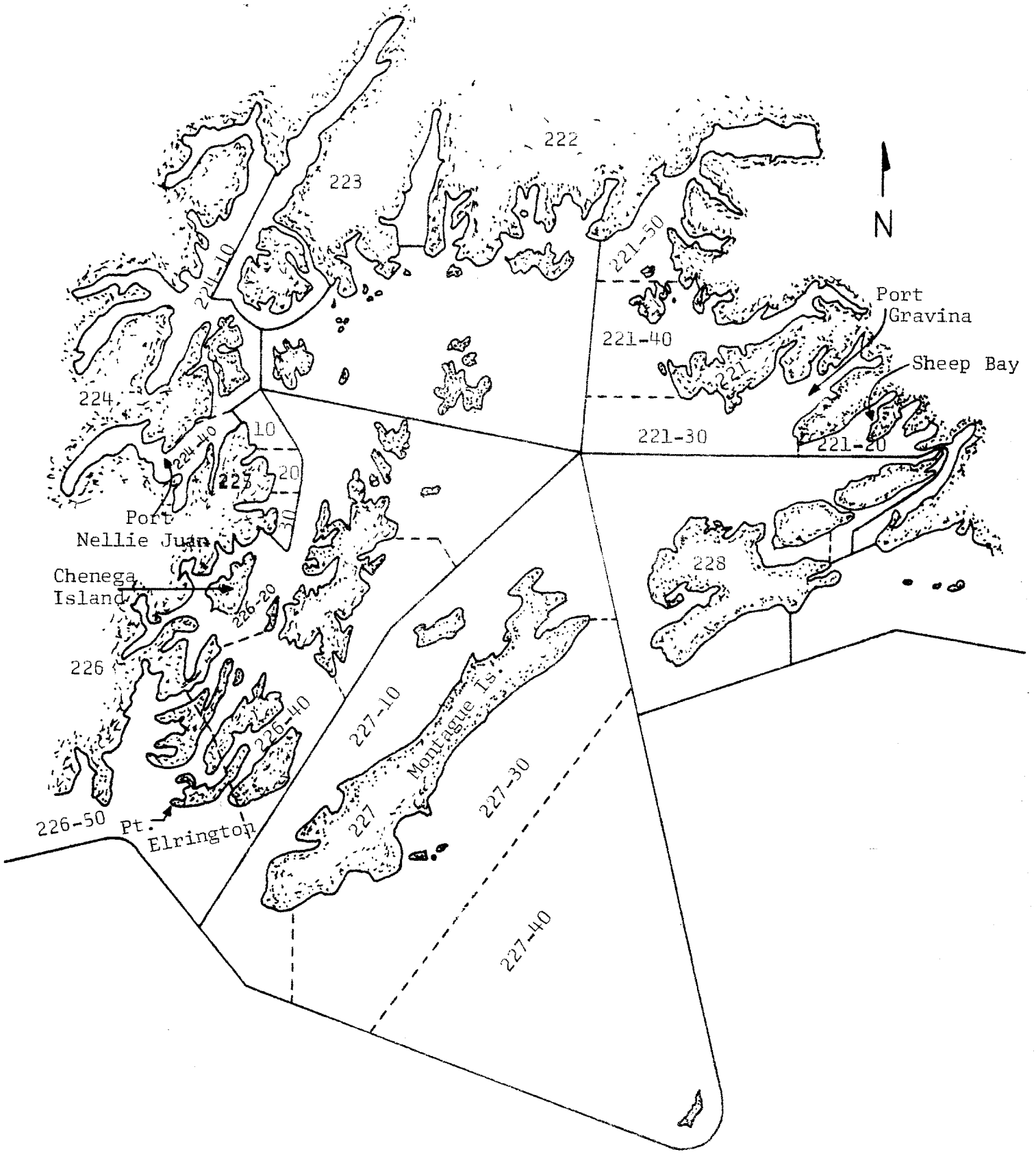


Figure 1. Alaska Department of Fish and Game Statistical Area Chart of Prince William Sound.

In 1964 the 1st annular radius measurement was defined as the longest distance from the center of the focus to the annular circuli in the anterior field of the scale. To determine the average distance between circuli, the radius distance measured on the projection surface of the scale reader was first converted into an unmagnified scale radius by dividing it by 80 (the magnification) and then secondarily dividing this actual radius value by the number of circuli interspaces between the focus and the annular circuli.

A slightly different method for determining the average distance between circuli was used for the 1963 scale sample because of the variability in the scale focus shape found in the 1964 sample. First, the longest straight-lin distance from the first circulus (as opposed to the center of the focus) to the annular circulus (in the anterior field of the scale) was measured on a radius through the center of the focus. This projected radial measurement was then converted to an unmagnified length by dividing by the projection magnification (80) and secondly, to an average circuli spacing by dividing by the number of circuli interspaces in the measured distance.

"t" tests at the .05 level of significance were used to test all data (Dixon & Massey, 1957).

Results of the 1964 data

1964 scales from Montague Island (ADF&G Statistical Area 227-10), 7/30/64 were read and measured twice in the prescribed manner and the results of a duplicate reading of the scales compared (Figure 2). The raw data is included in Appendix I and test of significance can be found in Appendix II. As the variance of the population from which the scale sample was drawn was not known, the following hypothesis was used: "The means of the two sampling distributions (first reading of scales and the second reading of scales) are the same when the variance of the population is unknown." The "t" test was not significant at the .05 level and therefore, the hypothesis was accepted as correct. This result means that duplicate readings of these scales fell within the limits of acceptable sampling error and that the scale measuring technique is reproducible at this significance level.

A comparison of circuli interspacing was then made between Montague Island (ADF&G Statistical Area 227-10), 7/30/64 scales and those from Port Nellie Juan (ADF&G Statistical Area 224-40), 7/25/64 (Appendix I and III). Again the "t" test proved insignificant at the .05 level (Appendix IV), therefore, the hypothesis was accepted that both of these area scale samples were drawn from the same population (Figure 3).

A third hypothesis was tested as to whether or not two random scale samples drawn from the same population of seine caught pink salmon had the same average 1st year circuli spacing. As both samples of scales were actually taken off fish from the same area (Port Nellie Juan, ADF&G Statistical Area 224-40) and on the same day (7/25/64) we would have expected the means of the average distance between the first year circuli to be similar. However, this finding was not verified at the .05 level of significance (Appendix III, V, and Figure 4). The possible reasons for the inequality in the circuli spacing

Figure 2. Histogram comparison of the first years circuli spacings from replicate readings of pink salmon scales from Montague Island (ADF&G Statistical Area 227-10), 7/25/64.

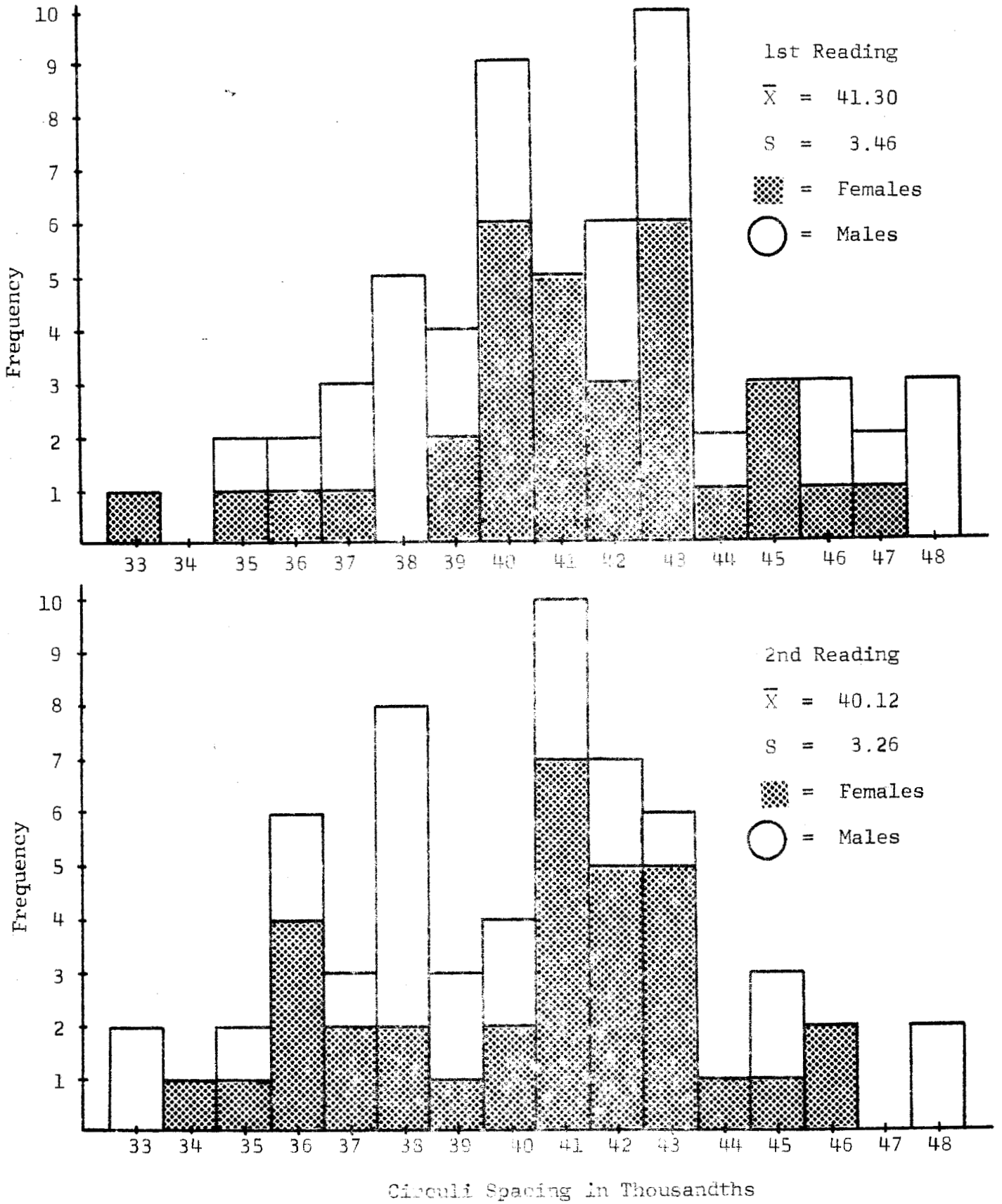


Figure 3. Histogram comparison of Port Nellie Juan (ADF&G Statistical Area 224-40), 7/25/64 and Montague Island (ADF&G Statistical Area 227-10), 7/25/64 mean pink salmon scale 1st year circuli spacings.

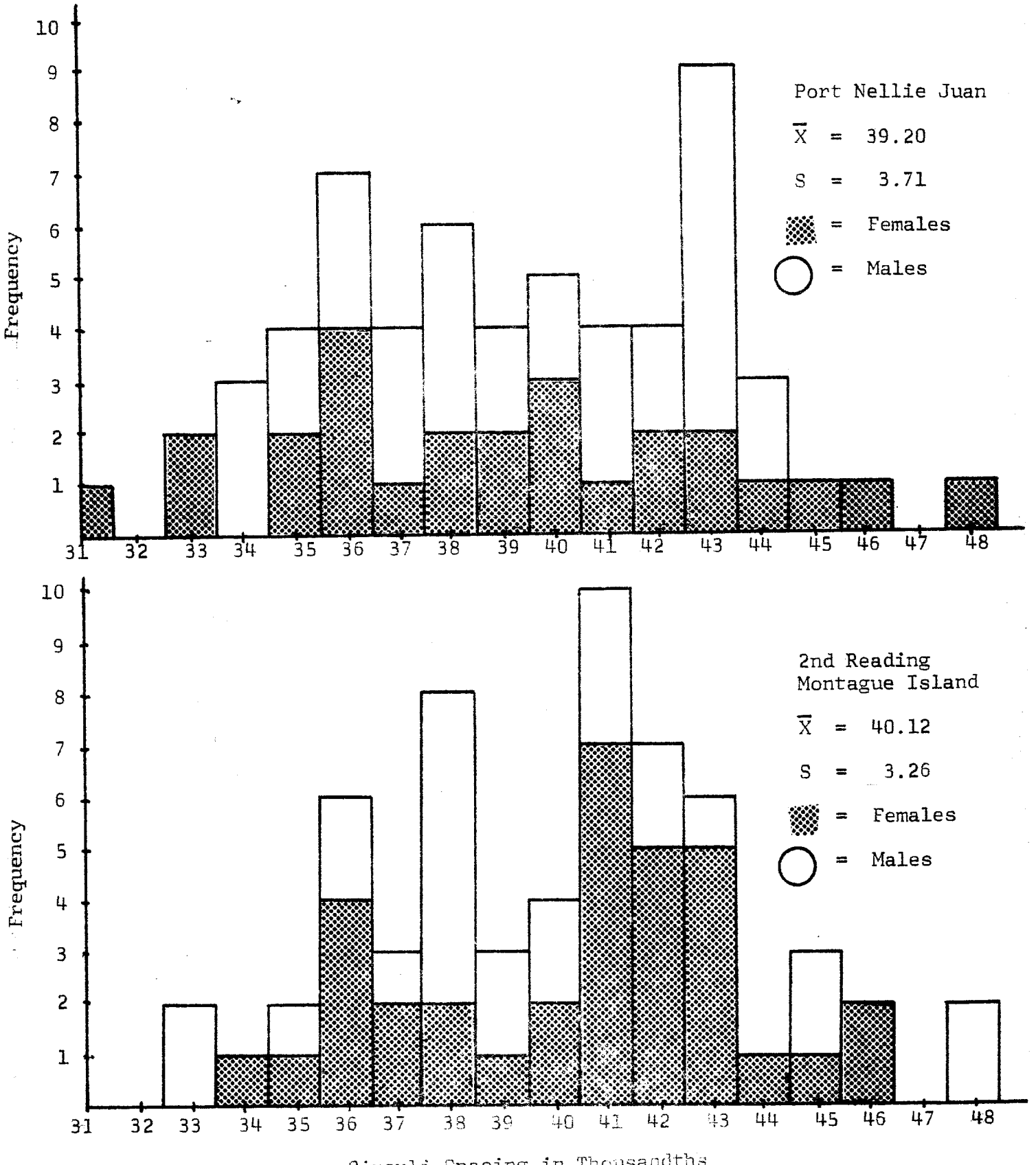
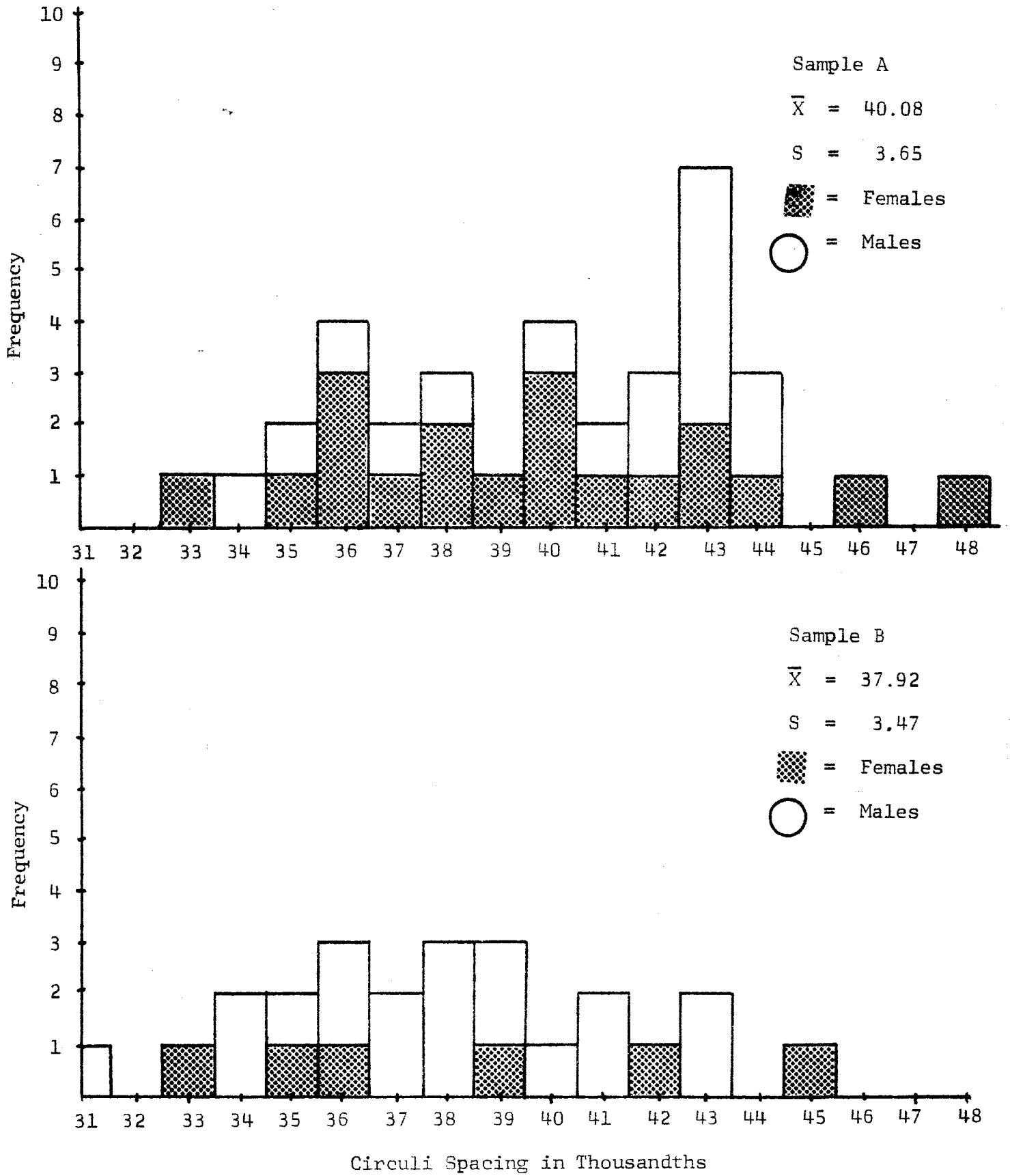


Figure 4. Histogram comparison of the mean first year circuli spacings in two samples of pink salmon scales from Port Nellie Juan (ADF&G Statistical Area 224-40), 7/25/64.



are: 1) the circuli spacing of fish from the same area is not the same, 2) the fish were not from the same area and a mixed population was sampled; or 3) the most plausible reason the sample size was too small to yield valid results as the hypothesis was non-significant at the .02 level (Appendix V). An estimate of an adequate sample size, using Chebyshev's inequality resulted in a value of 80 samples (Dixon & Massey, 1957) necessary to give conclusive results at the .05 level as to whether or not the scale samples from Port Nellie Juan were drawn from a population with equal first year circuli spacings. Therefore, the actual sample size of 22 scales was probably too small for obtaining valid conclusions.

Results of the 1963 data

Although the histograms of the 1963 data were of a similar type as the 1964 data, they cannot be directly compared as the measurement of the circuli spacing was by different methods (see METHODS section). All statistical tests between the 1963 samples were set at the .05 level of significance, the same as in the 1964 testing.

The first hypothesis tested was concerned with assessing the ability to duplicate the scale readings (reliability). For this test, two readings were made of the same set of scales from Pt. Elrington to Chenega Island (ADF&G Statistical Areas 226-20, 40 and 50), 7/30/63. For comparison of the distributions see Figure 5 and Appendix VI. A "t" test was computed to check the similarity of the means. The test (Appendix VII) proved insignificant. Therefore, it was concluded that dividing the distance between the first circulus and the annular circulus in the anterior field of the scale by the number of circuli interspaces was a reproducible and reliable method for obtaining an estimate of the average distance between first year circuli. Although both the 1963 and 1964 methods used in the determination of the circuli spacing proved valid and reproducible at the .05 level of significance, the method used on the 1963 scales is preferred as an arbitrary center to the focus does not have to be assigned. In designating a focus center there is the possibility of being in error if the measurements are not taken along the same axis each time as a result of the elliptical nature of some of the focusii. Another reason for preferring the 1963 method is that the distance from the center of the focus to the first circulus is usually considerably greater than the distance between the other first year circuli.

To test any possible differences in circuli spacing as a result of differences in the timing of run, the first year circuli spacing on late run pink salmon scales of Pt. Elrington to Chenega Island, 7/30/63 was compared with early run beach seine fish scales from Sheep Bay (ADF&G Statistical Area 227-20, 6/19/63). (See Figure 6 and Appendix VIII). The means proved unequal at the .05 level (Appendix IX) therefore, we can say that within this limited 1963 sample, the early fish from Sheep Bay and the late fish from Pt. Elrington to Chenega Island had different circuli spacing during the first year of growth. This difference in circuli spacing may be attributed either to the salmon being from different areas of the Sound or due to the difference in timing of the runs. However, a lack of scale samples throughout the season made the distinction impossible.

Figure 5. Histogram comparison of the first years circuli spacings from replicate readings of pink salmon scales from Point Elrington to Chenega Island area (ADF&G Statistical Areas 226-20, 226-40 and 226-50), 7/30/63.

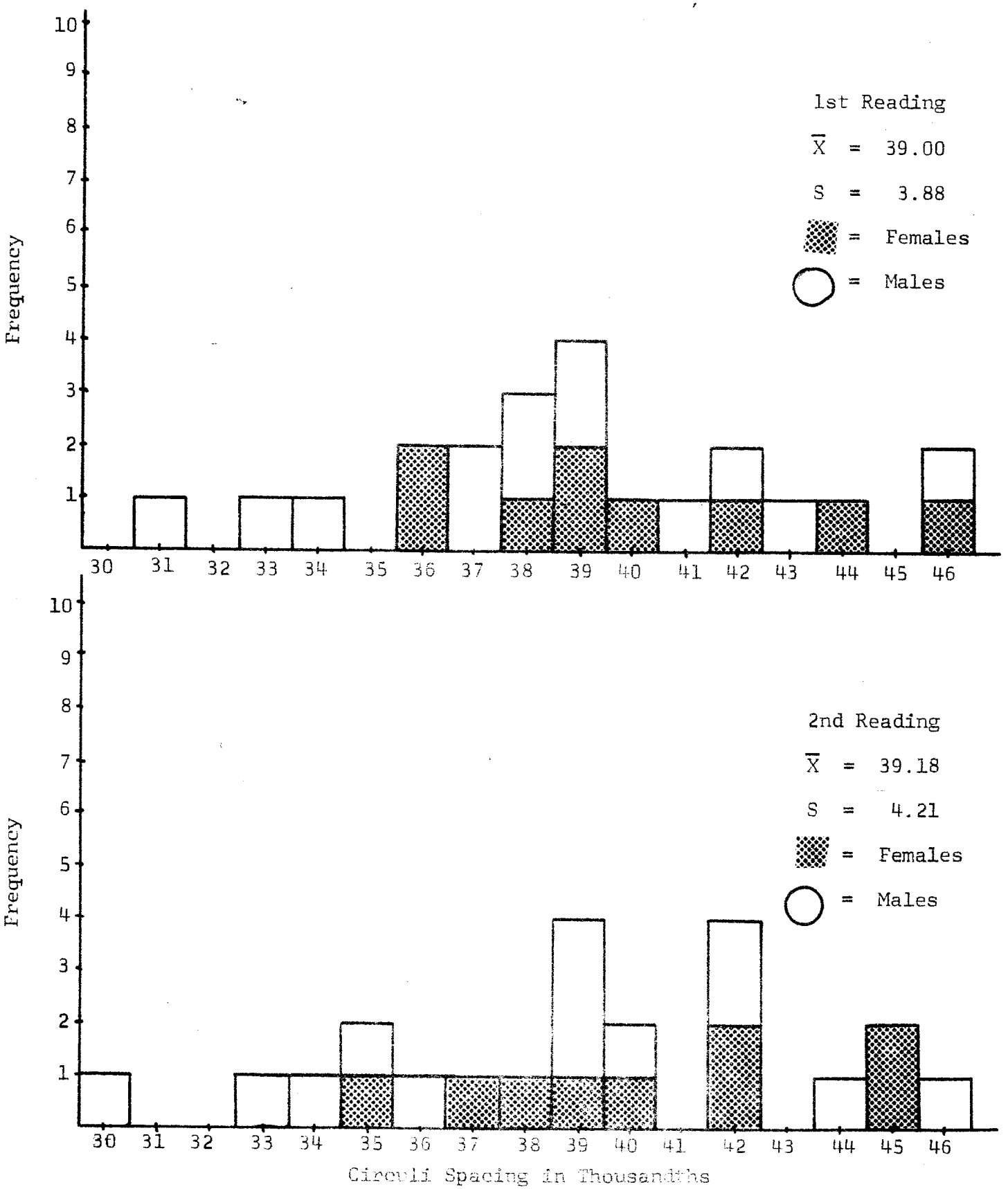
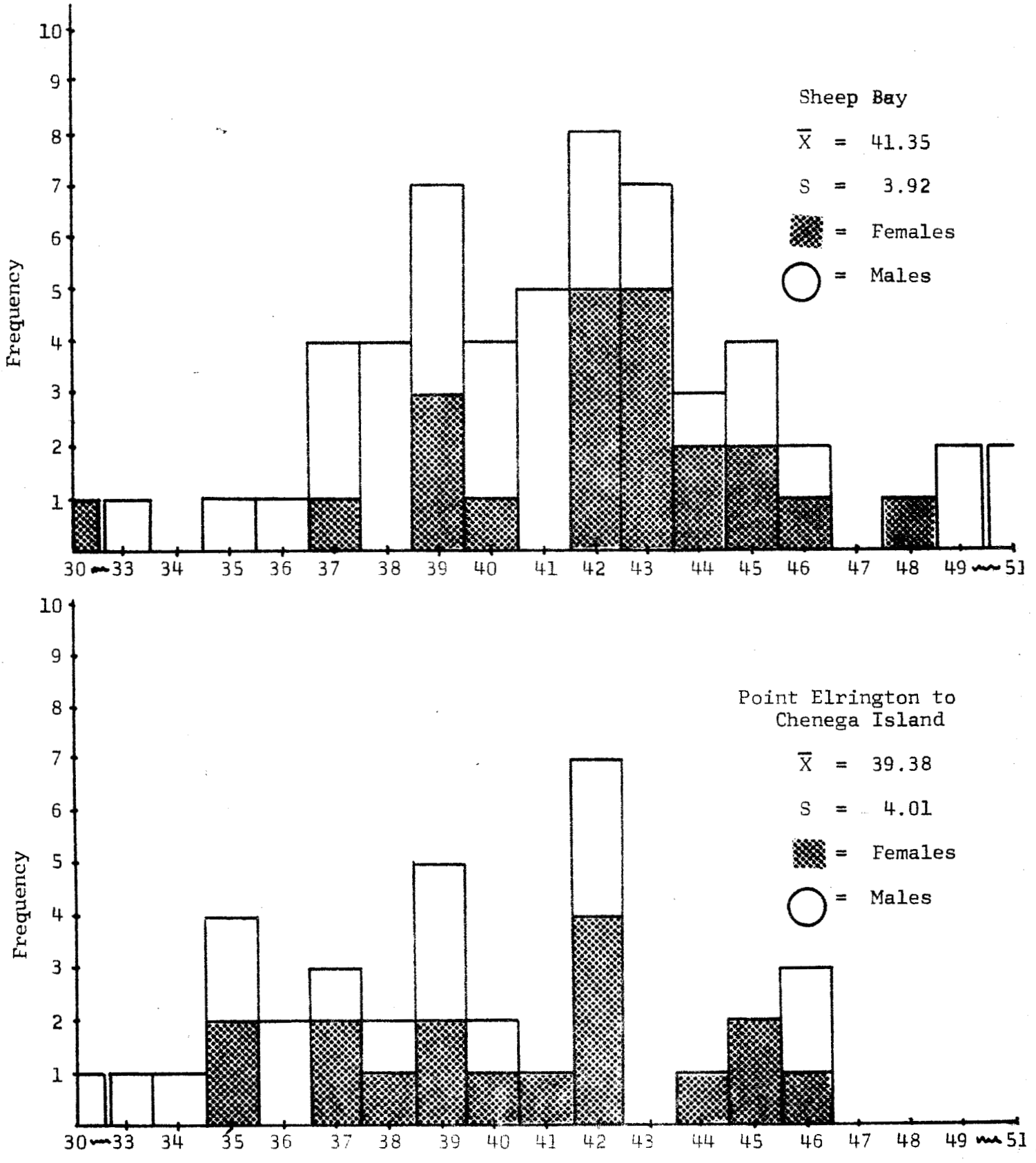


Figure 6. Histogram comparison of the first years mean circuli spacing on pink salmon scales from Sheep Bay (ADF&G Statistical Area 229-20) 6/19/63, and the Point Elrington to Chenega area (ADF&G Statistical Areas 226-20, 226-40 and 226-50) 7/30/63.



Circuli spacing differences were investigated between Port Gravina (ADF&G Statistical Area 221-30, 6/25/63) and the Sheep Bay (ADF&G Statistical Area 221-20, 6/19/63) area (Appendix X and VIII). The "t" test (Appendix XI) proved insignificant and, therefore, the hypothesis that the Port Gravina and Sheep Bay scales were taken from a population of fish with similar first year circuli growth patterns was accepted.

As the Port Gravina and Sheep Bay scales were similar in circuli spacing while the Sheep Bay and Pt. Elrington-Chenega Island were different (Figure 7), it was assumed that the Port Gravina and Pt. Elrington-Chenega Island scales were also different. However, no statistical test was conducted to verify this assumption. Again both timing of the run and area are involved in the differences.

The last comparison made was a check on the difference in circuli spacing between males and females (Appendix X). The Sheep Bay scale sample was the largest used in the study as it was the largest sample available. A "t" test (Appendix XII) was used to check for differences in the circuli spacings. The results were insignificant, with the conclusion that there was no difference in the first years spacing of circuli in male or female pink salmon from the same population (Figure 8).

CONCLUSIONS

1. Of the two methods used for measuring the distance between the first years circuli; the method whereby "the greatest distance (through the center of the focus in the anterior field of the scale) from the first circulus to the annular circulus was divided by the number of circuli interspaces" was preferred because of the irregularity of the focus shape. However, both measuring methods were reproducible at the .05 level of significance.

2. The 1964 circuli spacing for fish seined from Port Nellie Juan (7/25/64) and Montague Island (7/30/64) was the same.

3. There was a difference in circuli spacing of two small samples of pink salmon drawn from the same population in Port Nellie Juan, but the sample size may have been insufficient.

4. Optimum scale sample size for determining the difference between circuli spacing in different fish populations is around 80 scales per sample.

5. In 1963, the spacing of the first year's circuli on scales from the early run Sheep Bay (6/19/63) and the late run Pt. Elrington-Chenega Island (7/30/63) was different.

6. The first year circuli spacing on Pt. Gravina (6/25/63) and the Sheep Bay (6/19/63) scales was the same.

7. On the basis of conclusions (5) and (6) above, there was a probable difference in the first year's circuli spacing of the Pt. Elrington-Chenega area and the Port Gravina area scales.

Figure 7. Histogram comparison of the first years circuli spacing on pink salmon scales from Sheep Bay (ADF&G Statistical Area 221-20) 6/19/63 and Port Gravina (ADF&G Statistical Area 221-30) 6/25/63.

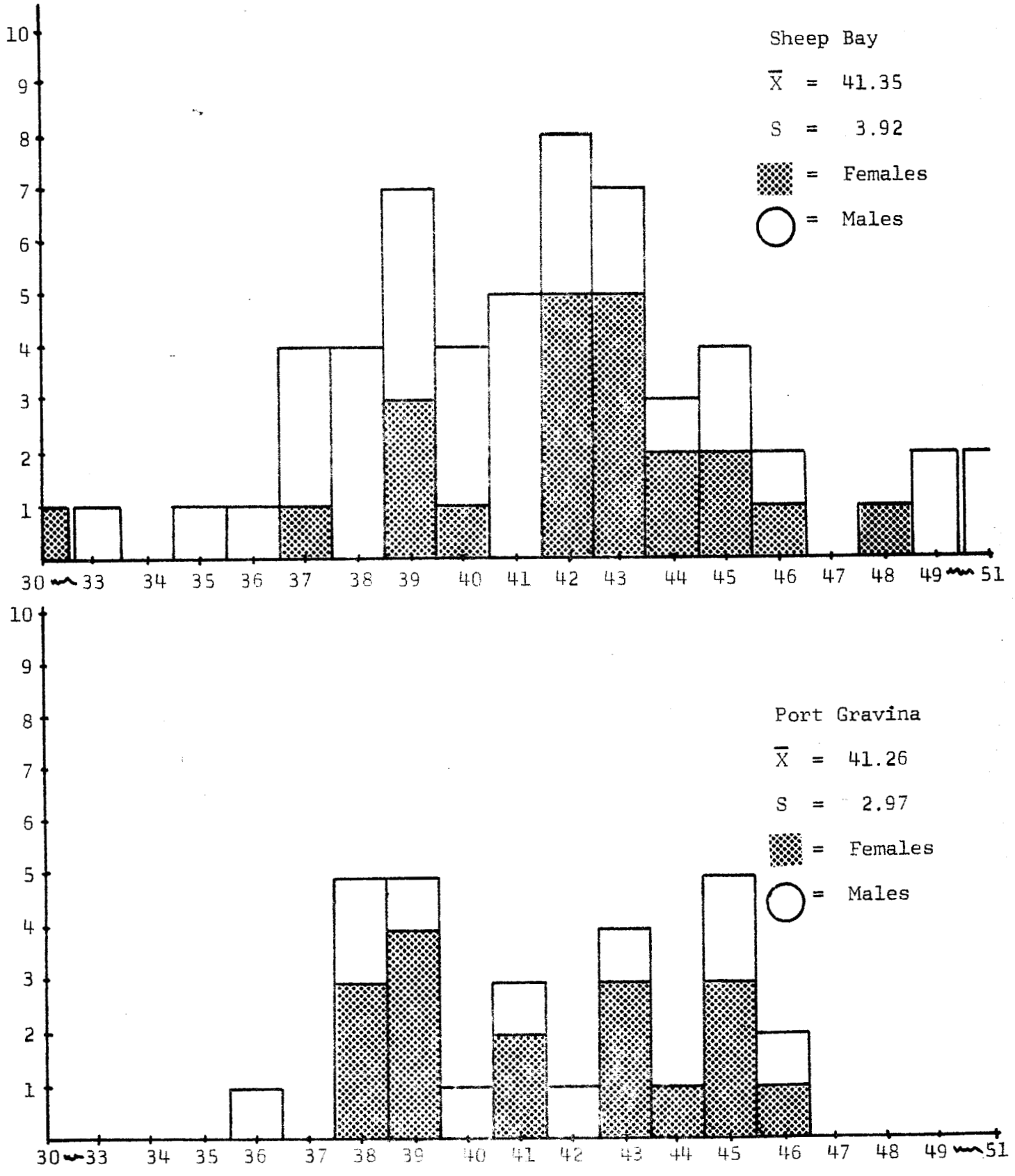
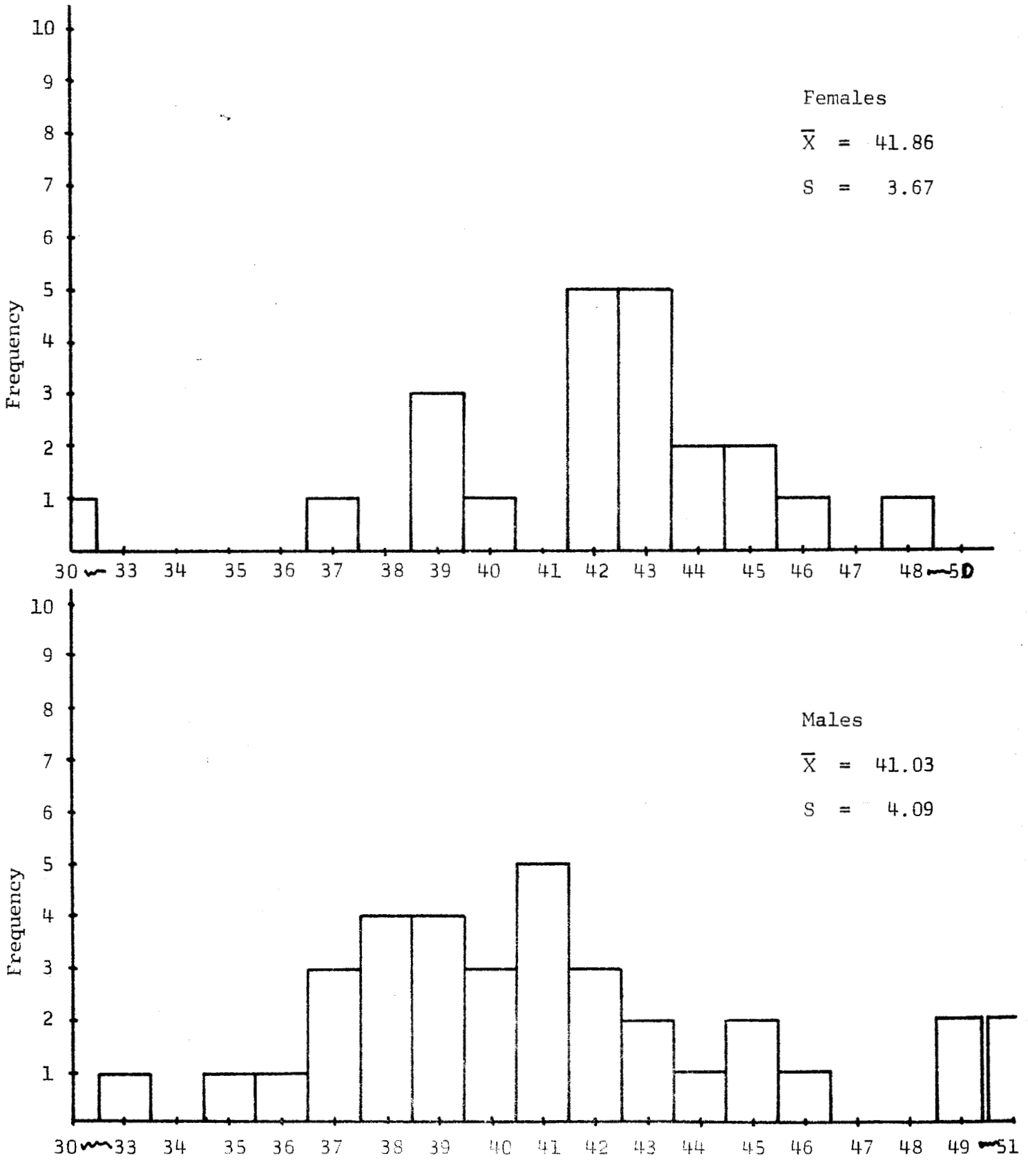


Figure 8. Histogram comparison of the first years circuli spacing on male and female pink salmon scales from Sheep Bay (ADF&G Statistical Area 221-20) 6/19/63.



8. The first year's circuli spacing in scales of the males and females from Sheep Bay was the same.

9. As only several thousandths of an inch separate the average first year circuli spacings on pink salmon scales from various areas of Prince William Sound, the use of this characteristic for separating stocks of pink salmon as they enter the Sound is not feasible with the present scale data.

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LIST OF SYMBOLS USED IN THE APPENDIX

x = distance between circuli in thousandths

f = frequency of occurrence

N = total size of the sample (Σf)

Σ = sum of

$\bar{X}$ = average circuli spacing in thousandths

s^2 = variance of the sample in thousandths

s = standard deviation of the sample in thousandths

s_p^2 = pooled variance of two samples

$t_{.05}$ = two-tailed "t" test with limits at the .05 level of significance

d.f. = degrees of freedom in the sample

APPENDIX I. FIRST YEAR CIRCULI SPACING ON PINK SALMON SCALES FROM MONTAGUE ISLAND (ADF&G STATISTICAL AREA 227-10) 7/30/64.

FIRST MEASUREMENT		SECOND MEASUREMENT	
x	f	x	f
33	1	33	2
34	0	34	1
35	2	35	2
36	2	36	6
37	3	37	3
38	5	38	8
39	4	39	3
40	9	40	4
41	5	41	10
42	6	42	7
43	10	43	6
44	2	44	1
45	3	45	3
46	3	46	2
47	2	47	0
48	3	48	2
SAMPLE SIZE	60		60
MEAN	41.30		40.12
VARIANCE	11.94915		10.64406
STANDARD DEVIATION	3.456		3.263

APPENDIX II. SIGNIFICANCE TEST OF THE ABILITY TO DUPLICATE CIRCULI MEASUREMENTS FROM MONTAGUE ISLAND (ADF&G STATISTICAL AREA 227-10) SEINE-CAUGHT PINK SALMON.

Hypothesis: The mean distance between the first year's circuli on pink salmon scales from Montague Island (ADF&G Statistical Area 221-20) as determined by two separate sets of measurements is the same even though the population variance is unknown.

$$t = \bar{X}_1 - \bar{X}_2 \,/\, s_p \sqrt{1/N_1 + 1/N_2}$$

$$s_p^2 = (N_1 - 1)s_1^2 + (N_2 - 1)\, s_2^2 \,/\, N_1 + N_2 - 2$$

$$s_p^2 = (60-1)(11.949) + (60-1)(10.644)/60 + 60 - 2$$

$$s_p^2 = 11.296 \qquad s_p = 3.36$$

$$t = 41.30 - 40.12 \,/\, 3.36 \sqrt{\frac{1}{60} + \frac{1}{60}} = 1.9246$$

$$df = 120 - 2 = 118 \qquad t_{.05} = 1.980$$

t of 1.9246 $<$ $t_{.05}$ of 1.980 therefore the hypothesis was accepted.

APPENDIX III. FIRST YEAR CIRCULI SPACING ON PINK SALMON SCALES FROM PORT NELLIE JUAN (ADF&G STATISTICAL AREA 224-40) 7/25/64.

SAMPLE A		SAMPLE B		SAMPLE A & B COMBINED	
x	f	x	f	x	f
33	1	31	1	31	1
34	1	32	0	32	0
35	2	33	1	33	2
36	4	34	2	34	3
37	2	35	2	35	4
38	3	36	3	36	7
39	1	37	2	37	4
40	4	38	3	38	6
41	2	39	3	39	4
42	3	40	1	40	5
43	7	41	2	41	4
44	3	42	1	42	4
45	0	43	2	43	9
46	1	44	0	44	3
47	0	45	1	45	1
48	1			46	1
				47	0
				48	1
SAMPLE SIZE	35		24		59
MEAN	40.08		37.92		39.20
VARIANCE	13.38		12.09		13.79
STANDARD DEVIATION	3.65		3.47		3.71

APPENDIX IV. SIGNIFICANCE TEST BETWEEN THE MEAN CIRCULI SPACING ON PINK SALMON SCALES FROM THE MONTAGUE ISLAND AREA (ADF&G STATISTICAL AREA 227-10) 7/30/64 AND FROM PORT NELLIE JUAN AREA (ADF&G STATISTICAL AREA 224-40) 7/25/64.

Hypothesis: The mean distance between first year scale circuli from pink salmon taken on the Montague Island grounds (ADF&G Statistical Area 227-10) 7/30/64 and those taken on the Port **Nellie** Juan grounds (ADF&G Statistical Area 224-40) 7/25/64 are the same even though the population variance is unknown.

$$t = \bar{X}_1 - \bar{X}_2 \;/\; s_p \sqrt{1/N_1 + 1/N_2}$$

$$s_p^2 = (N_1 - 1)(s_1^2) + (N_2 + 1)\, s_2^2 \;/\; N_1 + N_2 - 2$$

$$s_p^2 = (59)(10.644) + (58)(13.793) \;/\; 60 + 59 - 2 = 12.2050$$

$$s_p = 3.494$$

$$t = 40.116 - 39.203 \;/\; 3.494 \sqrt{1/60 + 1/59} = 1.4256$$

$$df = 60 + 59 - 2 = 117 \qquad t_{.05} = 1.980$$ (Table A-5 in Dixon & Massey)

t of 1.4256 $<$ $t_{.05}$ of 1.980 therefore the hypothesis was accepted.

APPENDIX V. SIGNIFICANCE TEST BETWEEN THE MEAN CIRCULI SPACINGS OF TWO SMALL SAMPLES OF SCALES TAKEN FROM THE SAME POPULATION OF FISH.

Hypothesis: The mean distance between pink salmon first year scale circuli from samples A and B, drawn from Port Nellie Juan (ADF&G Statistical Area 224-40) caught fish is the same even though the population variance is unknown.

$$t = \bar{X}_A - \bar{X}_B \; / \; s_p \sqrt{1/N_A + 1/N_B}$$

$$s_p^2 = (N_A - 1)\, s_A^2 + (N_B - 1)\, s_B^2 \; / \; N_A + N_B - 2$$

$$s_p^2 = (34)(13.38) + (23)(12.086)/35 + 24 - 2 = 12.8578$$

$$s_p = 3.59$$

$$t = 40.08 - 37.92 \; / \; 3.59 \sqrt{0.286 + .0417} = 2.2713$$

$$df = 35 + 24 - 2 = 57$$

$$t_{.05} = 2.005$$

$$t_{.02} = 2.395$$

t of 2.2713 $>$ $t_{.05}$ of 2.005 therefore the hypothesis was rejected at the .05 level of significance indicating the mean circuli spacings of samples A and B are different.

t of 2.2713 $<$ $t_{.02}$ of 2.395 therefore the hypothesis is acceptable at the .02 level of significance.

APPENDIX VI. FIRST YEAR CIRCULI SPACING ON PINK SALMON SCALES FROM THE POINT ELRINGTON TO CHENEGA ISLAND AREA (ADF&G STATISTICAL AREAS 226-20, 226-40 and 226-50).

FIRST MEASUREMENT		SECOND MEASUREMENT	
x	f	x	f
31	1	30	1
32	0	31	-
33	1	32	-
34	1	33	1
35	0	34	1
36	2	35	2
37	2	36	1
38	3	37	1
39	4	38	1
40	1	49	4
41	1	40	2
42	2	41	-
43	1	42	4
44	1	43	-
45	0	44	1
46	2	45	2
		46	1
SAMPLE SIZE	22		22
MEAN	39.00		39.18
VARIANCE	15.048		17.667
STANDARD DEVIATION	3.88		4.205

APPENDIX VII. SIGNIFICANCE TEST OF THE RELIABILITY OF DUPLICATING FIRST YEAR CIRCULI MEASUREMENT IN TWO SEPARATE READINGS OF THE POINT ELRINGTON AND CHENEGA ISLAND (ADF&G STATISTICAL AREAS 226-20, 226-40 and 226-50) SCALES.

Hypothesis: The mean distance between first year circuli on pink salmon scales from the Point Elrington to Chenega Island area as determined from two separate sets of measurements is the same even though the population variance is unknown.

$$t = \bar{X}_1 - \bar{X}_2 \,/\, s_p \sqrt{1/N_1 + 1/N_2}$$

$$s_p^2 = (N_1 - 1)\, s_1^2 + (N_2 - 1)\, s_2^2 \,/\, N_1 + N_2 - 2$$

$$s_p^2 = (21)(15.05) + (21)(17.67)/44 - 2$$

$$s_p^2 = 16.36 \qquad s_p = 4.04$$

$$t = 39.18\text{-}39.00/4.04 \sqrt{1/22 + 1/22} = .14778$$

$$df = 22 + 22 - 2 = 42 \quad t_{.05} = 2.02$$ (Table A-5 in Dixon and Massey)

t of .14778 $<$ $t_{.05}$ 2.021, therefore the hypothesis was accepted.

APPENDIX VIII. FIRST YEAR CIRCULI SPACING ON EARLY RUN PINK SALMON SCALES FROM SHEEP BAY (ADF&G STATISTICAL AREA 221-20) 6/19/63 AND LATE RUN FISH FROM POINT ELRINGTON TO CHENEGA ISLAND AREA (ADF&G STATISTICAL AREA 226-20, 226-40 and 226-50) 7/30/63.

Sheep Bay EARLY RUN MEASUREMENT		Point Elrington LATE RUN MEASUREMENT	
x	f	x	f
30	1	30	1
31	-	31	-
32	-	32	-
33	1	33	1
34	-	34	1
35	1	35	4
36	1	36	2
37	4	37	3
38	4	38	2
39	7	39	5
40	4	40	2
41	5	41	1
42	8	42	7
43	7	43	-
44	3	44	1
45	4	45	2
46	2	46	3
47	1		
48	1		
49	2		
50	-		
51	1		
SAMPLE SIZE	57		35
MEAN	41.351		39.38
VARIANCE	15.375		16.059
STANDARD DEVIATION	3.92		4.007

APPENDIX IX. TWO-TAILED "t" TEST CHECKING FOR A DIFFERENCE IN FIRST YEAR CIRCULI SPACING BETWEEN EARLY RUN PINK SALMON FROM SHEEP BAY (ADF&G STATISTICAL AREA 221-20) 6/15/63 AND LATE RUN FISH FROM POINT ELRINGTON TO CHENEGA ISLAND AREA (ADF&G STATISTICAL AREAS 226-20, 226-40 and 226-50) 7/30/63.

Hypothesis: The mean distance between scale circuli from early run pink salmon taken in Sheep Bay (ADF&G Statistical Area 227-10) on 6/15/63 and those taken on the late run Point Elrington to Chenega Island grounds (ADF&G Statistical Areas 226-20, 226-40 and 226-50) on 7/30/63 is the same even though the population variance is unknown.

$$t = \bar{X} - \bar{X} \,/\, s_p \sqrt{1/N + 1/N}$$

$$s_p^2 = (N-1)(s^2) + (N-1)(s^2) \,/\, N + N - 2$$

$$s_p^2 = (56)(15.375) + (34)(16.059) \,/\, 57 + 34 - 2$$

$$s_p^2 = 15.6334 \qquad s_p = 3.95$$

$$t = 41.35-39.38/3.95 \sqrt{1/57 + 1/35} = 2.26$$

$$df = 57 + 35 - 2 = 90 \qquad t_{.05} = 1.99 \text{ (Table A-5 in Dixon \& Massey)}$$

t of 2.26 $>$ $t_{.05}$ of 1.99 therefore the hypothesis was rejected and the means considered unequal.

$t_{.02} = 2.376$

t of 2.26 $<$ $t_{.02}$ of 2.376 therefore the hypothesis is accepted at the .02 level.

APPENDIX X. FIRST YEAR CIRCULI SPACING ON MALE AND FEMALE PINK SALMON FROM SHEEP BAY (ADF&G STATISTICAL AREA 221-20) 6/19/63 AND PINK SALMON FROM THE PORT GRAVINA FISHERY (ADF&G STATISTICAL AREA 221-30) 6/25/63.

A. SHEEP BAY				B. PORT GRAVINA	
#1 FEMALE MEASUREMENT		#2 MALE MEASUREMENT			
x	f	x	f	x	f
30	1	33	1	36	1
31	-	34	-	37	-
32	-	35	1	38	5
33	-	36	1	39	5
34	-	37	3	40	1
35	-	38	4	41	3
36	-	39	4	42	1
37	1	40	3	43	4
38	-	41	5	44	1
39	3	42	3	45	4
40	1	43	2	46	2
41	-	44	1		
42	5	45	2		
43	5	46	1		
44	2	47	1		
45	2	48	-		
46	1	49	2		
47	-	50	-		
48	1	51	1		
SAMPLE SIZE	22		35		27
MEAN	41.864		41.028		41.259
VARIANCE	13.476		16.735		8.808
STANDARD DEVIATION	3.67		4.09		2.97

APPENDIX XI. TWO-TAILED "t" TEST CHECKING FOR A DIFFERENCE IN THE FIRST YEAR MEAN CIRCULI SPACING BETWEEN PINK SALMON SCALES FROM THE SHEEP BAY (ADF&G STATISTICAL AREA 221-20) AND THE PORT GRAVINA (ADF&G STATISTICAL AREA 221-30) FISHERIES.

Hypothesis: The mean first year's circuli spacing on pink salmon scales from the Port Gravina (ADF&G Statistical Area 221-30) 6/25/63 and the Sheep Bay (ADF&G Statistical area 221-20) 6/19/63 is the same even though the population is unknown.

$$t = \bar{X}_1 - \bar{X}_2 \,/\, s_p \sqrt{1/N_1 + 1/N_2}$$

$$s_p^2 = (N_1 - 1)\, s^2 + (N_2 - 1)\, s^2 \,/\, N_1 + N_2 - 2$$

$$s_p^2 = (57-1)(15.375) + (27-1)(8.808) \,/\, 57 + 27 - 2$$

$$s_p^2 = 13.293 \qquad s_p = 3.64$$

$$t = 41.35 - 41.26 \,/(3.64)\left(\sqrt{1/57 + 1/27}\right) = .105$$

$$df = 27 + 57 - 2 = 82 \qquad t_{.05} = 1.990 \text{ (Table A-5 in Dixon \& Massey)}$$

t of .105 $< t_{.05}$ of 1.990 therefore the hypothesis was accepted.

APPENDIX XII. TWO-TAILED "t" TEST CHECKING FOR A DIFFERENCE IN THE FIRST YEAR'S CIRCULI SPACING BETWEEN MALE AND FEMALE PINK SALMON FROM SHEEP BAY (ADF&G STATISTICAL AREA 221-20) 6/19/63.

Hypothesis: The first year's mean circuli spacing on male and female pink salmon scales from Sheep Bay (ADF&G Statistical Area 221-20) 6/19/63 is the same even though the population variance is unknown.

$$t = \bar{X}_1 - \bar{X}_2 \,/\, s_p \sqrt{1/N_1 + 1/N_2}$$

$$s_p^2 = (N_1 - 1)\, s^2 + (N_2 - 1)\, s^2 \,/\, N_1 + N_2 - 2$$

$$s_p^2 = (22-1)(13.476) + (35-1)(16.735) \,/\, 22 + 35 - 2$$

$$s_p^2 = 15.4906 \qquad s_p = 3.935$$

$$t = 41.864 - 41.028 \,/\, 3.935 \sqrt{1/22 + 1/35} = .7813$$

$$df = 22 + 35 - 2 \qquad t_{.05} = 2.01$$ (Table A-5 in Dixon & Massey)

t of .7813 $< t_{.05}$ of 2.01 therefore the hypothesis was accepted.

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