# INDEPENDENT FORECASTS FOR COLUMBIA RIVER EARLY AND LATE RUN COHO SALMON ABUNDANCE IN 1987

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## INTRODUCTION

In 1987, as in prior years, the OPI Technical Committee has devoted a considerable amount of time discussing various methods that could improve the precision of the forecast. Many of the same issues that have arisen in previous years meeting arose again this year including whether to adjust jacks for delayed release, whether to add Oregon coastal natural (OCN) escapement in the OPI regression relationship, and how to partition the OPI forecast into stock components. The consensus opinions on these issues varied to some degree and, consequently, several variations of OPI component forecasts were generated at Technical Team, PFMC, and Salmon Team meetings. Individual opinions varied from what some considered an overly pessimistic OPI forecast that, unless modified, would surely result in foregone harvest to what some considered an overly optimistic OCN forecast that could probably result in underescapement.

The purpose of this memo is to present for discussion at a future unharried time, forecasting methods for Columbia River early and late coho, modeled for 1987.

## BACKGROUND

Forecasts for Columbia River early and late coho abundance have been made with mediocre results. For example, a linear regression based forecast for 1985 late coho was about one-half the actual total production. This error, however, cannot be totally unexpected since the 1985 jack abundance was a record low and, therefore, out of the data base range. Regression generated forecasts utilized Cowlitz plus Lewis hatcheries jack returns for the late stock predictor and Oregon hatcheries plus Willamette Fall jack counts for the early stock forecast. In both cases, jacks were adjusted for delayed release and all years except 1983 were incorporated into the regressions.

Due partly to the forecasting imprecision of the early and late stock predictors, the Columbia River stock forecasts were based on another method in 1986 and 1987. In these years a public hatchery production estimate was calculated by subtracting the OCN estimate (OPI area catch only in 1986; catch and escapement in 1987) from the OPI forecast. (In 1986 and earlier OCN escapement was not included in the OPI estimate, whereas it was included in 1987.). The public hatchery production portion was then stratified by smolt release proportions of four main groups: Columbia River earlies, Columbia River lates, Oregon coastal hatchery, and Rogue/Klamath. Columbia River smolt releases typically comprise over 80% of the total public hatchery production. Likewise, most of the OPI is comprised of Columbia River production, roughly estimated at 60-80%. OCN contribution seldom exceeds 30-35% of the total. Because of the OCN subtraction method, the magnitude of the Columbia River forecasts are highly linked to the precision of the OPI and OCN forecasts. In a sense, Columbia River stock abundance is indirectly estimated based on OCN abundance. Since the OPI has a long standing reliability and the Columbia River production is the dominant component of the OPI, it seems more appropriate to estimate OCN by subtraction rather than vice versa.

Estimating OCN by subtraction disregards the differences in parent brook escapement, which for the 1987 forecast is the largest since 1971 (1974 return year). The 1987 OCN forecast of 458.0K might be considered the "acid-test" for OCN estimating procedures since this years run is forecasted to be much larger than recent run sizes and a much greater portion of the total OPI than normally observed (Table 1). Depending on the 1987 outcome, developing independent forecasts for OCN and Columbia River stocks (as described below) may become the preferred approach rather than using subtraction to yield one of the components.

COLUMBIA RIVER EARLY COHO PREDICTOR

As previously mentioned, attempts have been made at determining satisfactory independent forecasts of total early coho stock abundance where total stock size was estimated by dividing ocean escapement by (1 - OPI area harvest rate). The primary regression relationship investigated (jacks at Oregon hatcheries and Willamette Falls) yielded 1987 estimates of between 0.6-1.0M total early stock run size (Regr. 1,2). An alternative regression using unadjusted jacks at Oregon hatcheries, Willamette Falls, and Bonneville Dam (after age adjustments) yielded a forecast of 331.6K (Figure 1; Regr. 3). The adjusted jack counterpart yielded a forecast of over 600K (Regr. 4). Correlation, standard error, and residuals were similar in both of these equations. The 331.6K estimate seems more appropriate since the 1987 OPI area forecast is based on unadjusted jacks. Magnitude seems more reasonable also.

COLUMBIA RIVER LATE COHO PREDICTOR

Forecasting late coho is complicated by the fact that WDF hatchery returns have only been segregated by stock since 1982. This is not a problem for Cowlitz Hatchery where all production is considered late stock. There is difficulty incorporating into the forecasting method production at Lewis River Hatchery, the other major producer of late stock coho, where production greatly increased beginning with the 1979 brood. In order to account for this increased production and still solve the dilemma of not segregating hatchery returns prior to 1982, the Lewis system late coho jack count is estimated as the number of late stock jacks above the background level (preenhancement) calculated from smolt release proportions.

A good late stock predictor was revealed when total adult production was compared to production by year. For unknown reasons, productions during odd numbered years is consistently poorer than during even years (Figure 2). Correspondingly, regression equations would be expected to be different also, either in slope, intercept or both. Regressing combined unadjusted jacks from Cowlitz and Lewis hatcheries to total adult production resulted in an especially tight relationship for odd years (R-squared = .92) and a 1987 forecast of 244.8K (Figure 3; Regr. 5). The adjusted jack relationship had a similar, but slightly higher, correlation (R-squared=.94) and 1987 forecast of 257.1K (Regr. 6). Once again the value based on unadjusted jacks seemed more appropriate since OPI production was based on the unadjusted jack regression.

## OPI PARTITIONING USING INDEPENDENT COLUMBIA RIVER FORECASTS

If subtraction is utilized to partition OPI production, then the regression generated forecasts for Columbia River stocks result in changes to the other stock components. OCN reduces to 230.5K from 458.0K (Table 2). The other public hatchery components increase if the smolt release proportion method is retained. If independent forecasts for Columbia River and OCN stocks ar used, then total OPI area stock abundance (excluding private hatcheries) increases to 1162.2K, a 24% increase over the Salmon Team's forecast of 934.7K and a 12% increase over the PFMC adopted value of 1041.5K.

## SUMMARY

1. Using subtraction to partition the OPI area coho stock abundance can result in radically different forecasts for the component parts, depending on which particular stock is independently forecasted and subtracted.

2. Investigation of independent forecasting procedures should continue for the major OPI area contributors.

3. Forecasting methods should be consistently applied every year until it is reasonably determined that another method is superior.

4. The method should be chosed first on its biological and statistical merits then on its forecast, not vice versa.

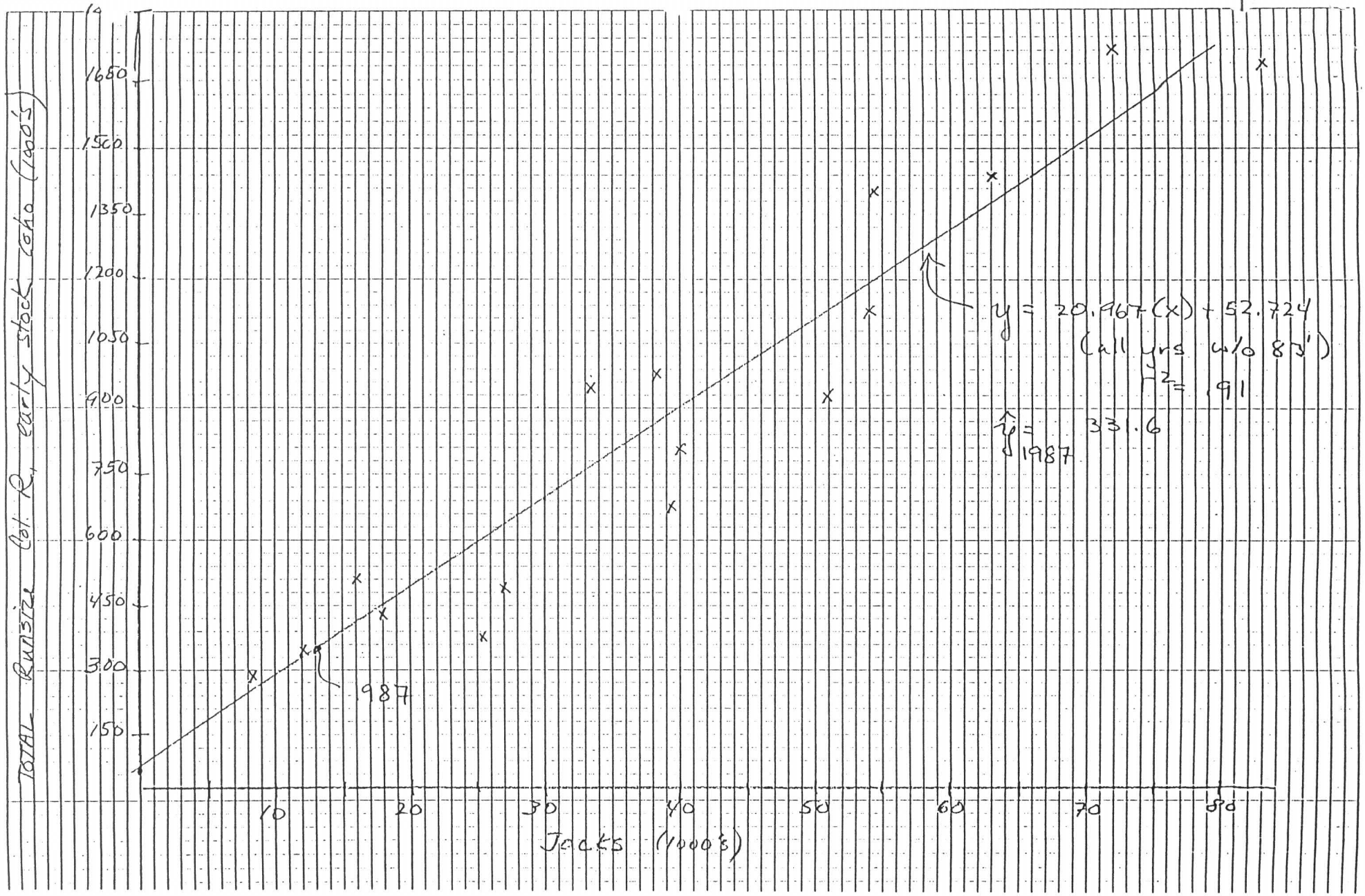


Figure 1. Relationship of Columbia River early stock coho jack returns (adjusted for delayed release) at Oregon hatcheries, Bonneville Dam and Willamette Falls to total adult production 1970-86.

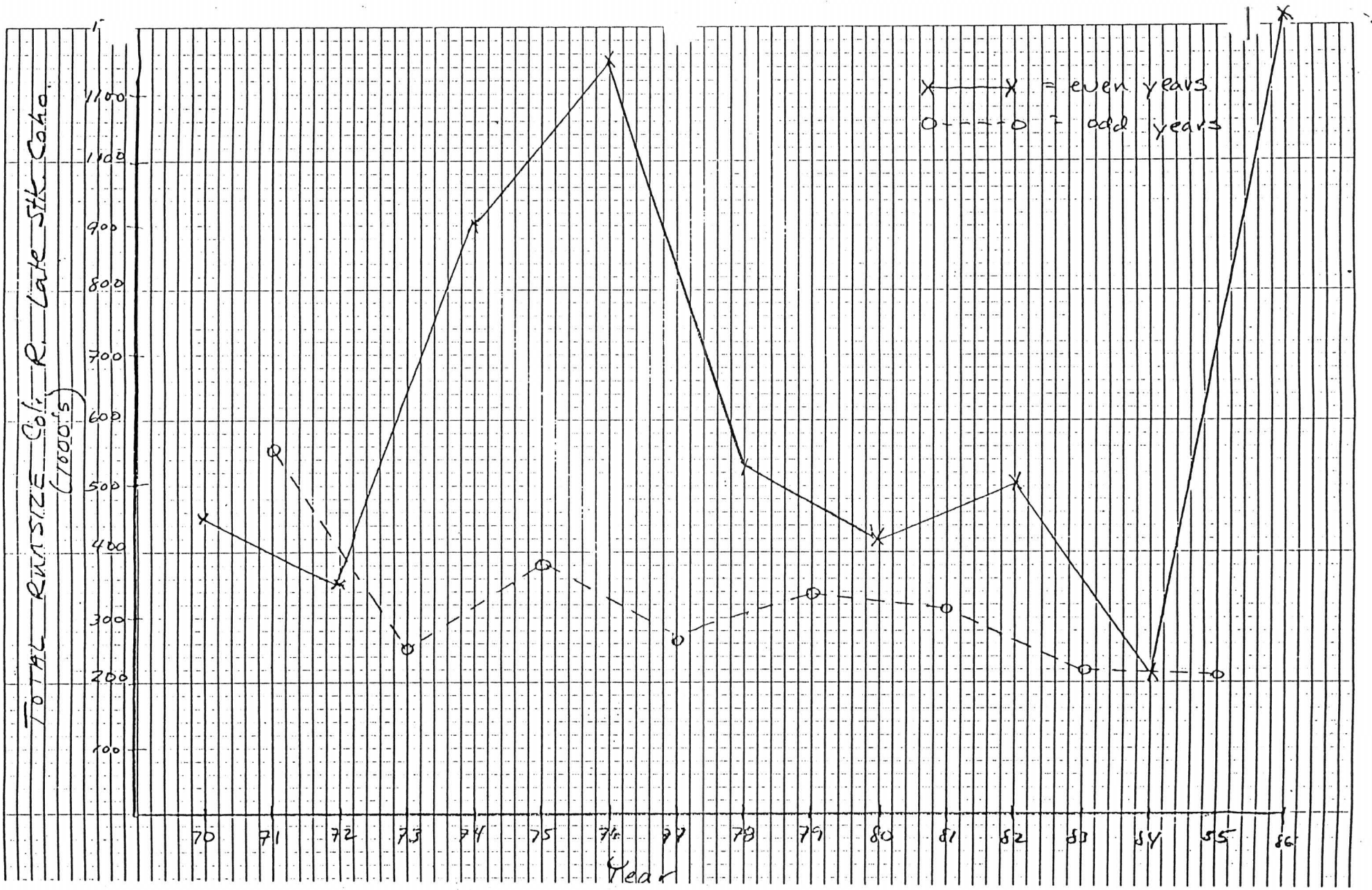


Figure 2. Columbia River late stock coho production on odd vs. even years, 1970-86.

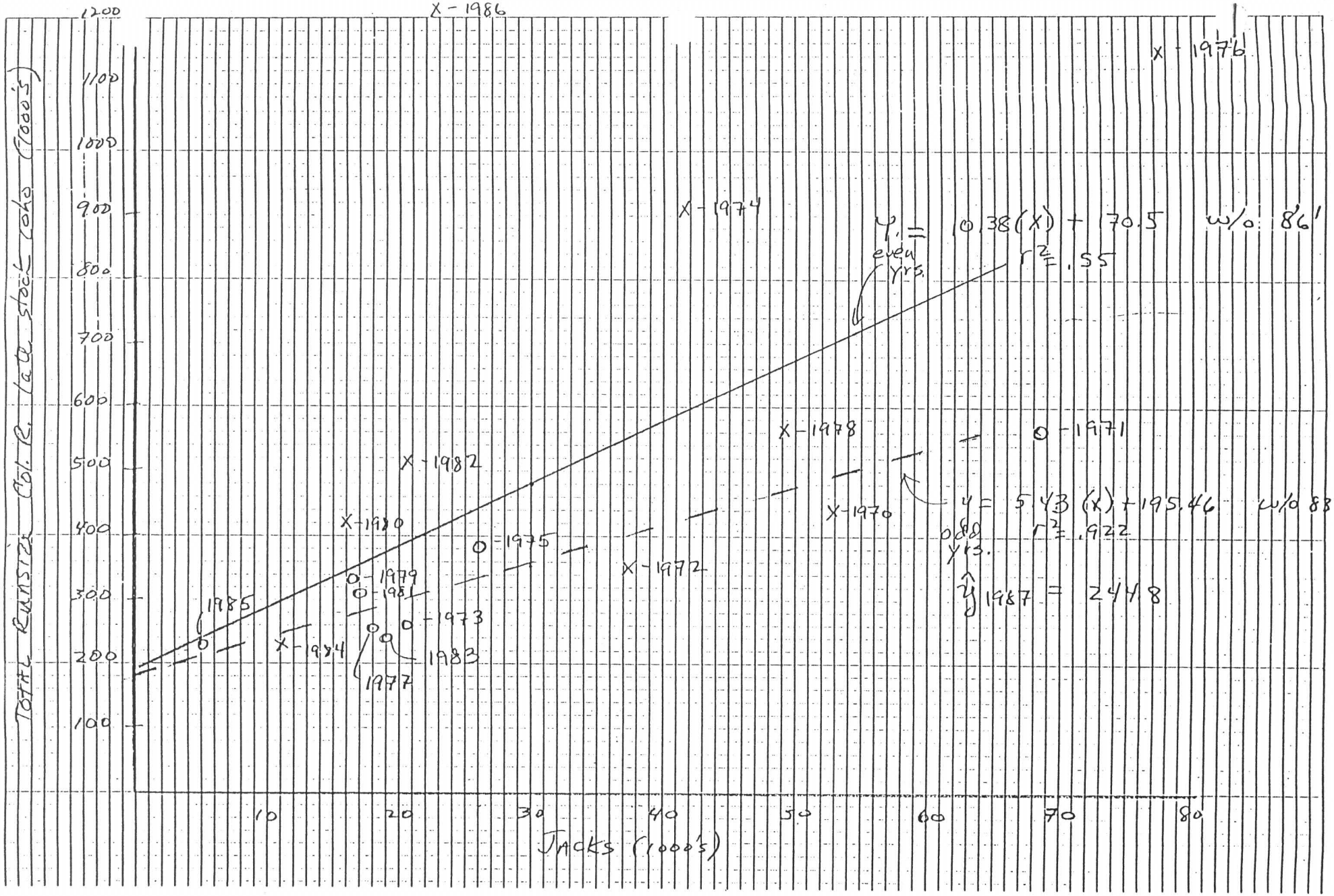


Figure 3. Relationship of Cowlitz plus Lewis Hatchery jacks (unadjusted for delayed releases) to odd vs. even year total adult production, 1970-86.

Table 1. Oregon coastal natural (OCN) forecasting parameters and resultant run sizes 1981-87.

| Adult return year (t) | Total run size[a/] | Parent brood spawners | Σ peak jack count (t-1) | Jacks/mile (t-1) | OCN as percent of OCN + OPI + Ten Mile Lakes[a/] |
|---|---|---|---|---|---|
| 1981 | 367.0 | 74.5 | 285 | 5.5 | 29.2 |
| 1982 | 338.1 | 172.5 | 76 | 1.6 | 23.2 |
| 1983 | 258.3 | 107.5 | 264 | 6.6 | 35.2 |
| 1984 | 291.0 | 72.7 | 103 | 1.9 | 32.7 |
| 1985 | 316.1 | 128.6 | 160 | 3.0 | 33.8 |
| 1986 | 264.7[b/] | 57.2 | 264 | 5.2 | 10.4 |
| 1987 | (458.0) | 200.1 | 139 | 2.7 | 49.0 |

a/ Values from Appendix I
b/ Preliminary approximation.

Table 2. Coho production in the OPI area based on several jack-to-adult forecasting methods.

| Production source | Population abundance (1,000's) PFMC (adjusted jacks) | Salmon team 1987 proposed (unadjusted jacks) | PFMC 1987 adopted (team +add-ons; unadjusted jacks) | Salmon Team with Columbia River independent (unadjusted jacks) | "All" independent (unadjusted jacks |
|---|---|---|---|---|---|
| Total (less private hatcheries[a/] | 1,239.0 | 934.7 | 1,041.5 | 934.7 | 1,162.2 |
| Columbia River | | | | | |
| Early | 351.0[b/] | 211.0[b/] | 211.0 + 87.4 | 331.6 | 331.6 |
| Late | 290.0[b/] | 174.3[b/] | 174.3 + 19.4 | 244.8 | 244.8 |
| Oregon coastal hatchery | 91.6[b/] | 55.1[b/] | 55.1 | 82.4[b/] | 82.4[b/] |
| Rogue/Kalamath | 30.4[b/] | 18.3[b/] | 18.3 | 27.4[b/] | 27.4[b/] |
| Ten Mile Lakes | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 |
| Subtotal | 781.0 | 476.7 | 583.5 | 704.2 | 704.2 |
| OCN | 458.0 | 358.0 | 458.0 | 230.5 | 458.0 |

a/ Includes OPI plus OCN and Ten Mile Lake escapements.
b/ Partitioned based on smolt release proportions of all public hatchery production (Columbia River early - 46.0%, Columbia River late - 38.0%; Oregon coastal hatchery - 12.0%; Rogue/Kalamath - 4.0%.

REGR 1 : Oregon hatcheries and Will. Falls jacks unadjusted for delayed release; all years 1970-86, but 1983

| year | ind varble | dep varble | | | X^2 | | Y^2 | X*Y | Expect Values | Devia tion | % Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 46.9 | 1731.1 | count | 16 | 2199.6 | 2996783.3 | 81189.6 | 1633.2 | 97.9 | 5.7 | 0.3 |
| 1971 | 57.9 | 1680.6 | mean X | 21.5 | 3352.4 | 2824302.4 | 97304.8 | 1955.6 | -275.0 | -16.4 | -1.0 |
| 1972 | 28.5 | 936.4 | mean Y | 888.6 | 812.3 | 876933.3 | 26688.7 | 1094.0 | -157.5 | -16.8 | -1.8 |
| 1973 | 22.4 | 1175.4 | sum X | 343.9 | 501.8 | 1381536.5 | 26328.7 | 915.2 | 260.2 | 22.1 | 1.9 |
| 1974 | 34.5 | 1440.8 | sum Y | 14218.3 | 1190.3 | 2075785.4 | 49706.2 | 1269.8 | 171.0 | 11.9 | 0.8 |
| 1975 | 11.1 | 801.7 | sumX^2 | 10840.5 | 123.2 | 642725.5 | 8898.9 | 584.0 | 217.7 | 27.1 | 3.4 |
| 1976 | 29.3 | 1398.9 | sumY^2 | 16111406.5 | 858.5 | 1956882.6 | 40987.4 | 1117.4 | 281.5 | 20.1 | 1.4 |
| 1977 | 8.9 | 364.9 | sum X*Y | 406673.6 | 79.2 | 133147.8 | 3247.6 | 519.6 | -154.7 | -42.4 | -11.6 |
| 1978 | 28.2 | 978.0 | Beta-est | 29.3 | 795.2 | 956406.0 | 27578.5 | 1085.2 | -107.2 | -11.0 | -1.1 |
| 1979 | 17.4 | 659.3 | Alpha-est | 258.7 | 302.8 | 434722.3 | 11472.4 | 768.7 | -109.3 | -16.6 | -2.5 |
| 1980 | 11.3 | 487.2 | Reg SS | 2961960.4 | 127.7 | 237370.1 | 5505.4 | 589.9 | -102.7 | -21.1 | -4.3 |
| 1981 | 9.2 | 445.7 | Total SS | 3476470.3 | 84.6 | 198616.1 | 4100.1 | 528.4 | -82.7 | -18.6 | -4.2 |
| 1982 | 7.7 | 519.8 | Res MS | 36750.7 | 59.3 | 270191.8 | 4002.5 | 484.4 | 35.4 | 6.8 | 1.3 |
| 1983 | | | R^2 | 0.85 | 0.0 | 0.0 | 0.0 | 258.7 | -258.7 | ERR | ERR |
| 1984 | 6.9 | 299.7 | S | 191.7 | 47.6 | 89840.4 | 2068.2 | 461.0 | -161.2 | -53.8 | -17.9 |
| 1985 | 8.3 | 339.0 | | | 68.9 | 114906.7 | 2813.5 | 502.0 | -163.0 | -48.1 | -14.2 |
| 1986 | 15.4 | 959.8 | calculated y for x= | | 237.2 | 921256.3 | 14781.2 | 710.1 | 249.8 | 26.0 | 2.7 |
| | | | 11.5 | | | | | | | | |
| | | | 595.8 | | | | | | | | |

REGR 2 : Oregon hatcheries and Will. Falls jacks adjusted for delayed release; all years 1970-86, but 1983

| year | ind varble | dep varble | | | X^2 | | Y^2 | X*Y | Expect Values | Devia tion | % Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 46.9 | 1731.1 | count | 16 | 2199.6 | 2996783.3 | 81189.6 | 1636.2 | 94.9 | 5.5 | 0.3 |
| 1971 | 57.9 | 1680.6 | mean X | 22.0 | 3352.4 | 2824302.4 | 97304.8 | 1966.3 | -285.7 | -17.0 | -1.0 |
| 1972 | 28.5 | 936.4 | mean Y | 888.6 | 812.3 | 876933.3 | 26688.7 | 1084.1 | -147.6 | -15.8 | -1.7 |
| 1973 | 22.4 | 1175.4 | sum X | 351.8 | 501.8 | 1381536.5 | 26328.7 | 901.0 | 274.4 | 23.3 | 2.0 |
| 1974 | 34.5 | 1440.8 | sum Y | 14218.3 | 1190.3 | 2075785.4 | 49706.2 | 1264.1 | 176.6 | 12.3 | 0.9 |
| 1975 | 11.1 | 801.7 | sumX^2 | 11071.8 | 123.2 | 642725.5 | 8898.9 | 561.9 | 239.8 | 29.9 | 3.7 |
| 1976 | 29.3 | 1398.9 | sumY^2 | 16111406.5 | 858.5 | 1956882.6 | 40987.4 | 1108.1 | 290.8 | 20.8 | 1.5 |
| 1977 | 8.9 | 364.9 | sum X*Y | 412748.9 | 79.2 | 133147.8 | 3247.6 | 495.9 | -131.0 | -35.9 | -9.8 |
| 1978 | 28.2 | 978.0 | Beta-est | 30.0 | 795.2 | 956406.0 | 27578.5 | 1075.1 | -97.1 | -9.9 | -1.0 |
| 1979 | 17.4 | 659.3 | Alpha-est | 228.8 | 302.8 | 434722.3 | 11472.4 | 751.0 | -91.6 | -13.9 | -2.1 |
| 1980 | 12.9 | 487.2 | Reg SS | 3004571.1 | 166.4 | 237370.1 | 6285.0 | 615.9 | -128.7 | -26.4 | -5.4 |
| 1981 | 10.6 | 445.7 | Total SS | 3476470.3 | 112.4 | 198616.1 | 4724.0 | 546.9 | -101.3 | -22.7 | -5.1 |
| 1982 | 9.2 | 519.8 | Res MS | 33707.1 | 84.6 | 270191.8 | 4782.2 | 504.9 | 14.9 | 2.9 | 0.6 |
| 1983 | | | R^2 | 0.86 | 0.0 | 0.0 | 0.0 | 228.8 | -228.8 | ERR | ERR |
| 1984 | 6.7 | 299.7 | S | 183.6 | 44.9 | 89840.4 | 2008.2 | 429.9 | -130.2 | -43.4 | -14.5 |
| 1985 | 7.5 | 339.0 | | | 56.3 | 114906.7 | 2542.3 | 453.9 | -114.9 | -33.9 | -10.0 |
| 1986 | 19.8 | 959.8 | calculated y for x= | | 392.0 | 921256.3 | 19004.5 | 823.0 | 136.8 | 14.3 | 1.5 |
| | | | 27.2 | | | | | | | | |
| | | | 1045.1 | | | | | | | | |

REGR 3 :Oregon hatchery, Bonneville Dam, Willamette Falls jacks unadjusted for delayed release; all years 1970-86, but 1983

| ——r | ind varble | dep varble | | | X^2 | | Y^2 | X*Y | Expect Values | Devia tion | % Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 72.1 | 1731.1 | count | 16 | 5198.4 | 2996783.3 | 124813.9 | 1564.4 | 166.7 | 9.6 | 0.6 |
| 1971 | 83.1 | 1680.6 | mean X | 39.9 | 6905.6 | 2824302.4 | 139655.0 | 1795.1 | -114.5 | -6.8 | -0.4 |
| 1972 | 50.7 | 936.4 | mean Y | 888.6 | 2570.5 | 876933.3 | 47477.9 | 1115.7 | -179.3 | -19.1 | -2.0 |
| 1973 | 54.1 | 1175.4 | sum X | 637.9 | 2926.8 | 1381536.5 | 63588.5 | 1187.0 | -11.6 | -1.0 | -0.1 |
| 1974 | 63.3 | 1440.8 | sum Y | 14218.3 | 4006.9 | 2075785.4 | 91200.0 | 1379.9 | 60.8 | 4.2 | 0.3 |
| 1975 | 40.4 | 801.7 | sumX^2 | 32613.6 | 1632.2 | 642725.5 | 32388.7 | 899.8 | -98.1 | -12.2 | -1.5 |
| 1976 | 54.8 | 1398.9 | sumY^2 | 16111406.5 | 3003.0 | 1956882.6 | 76659.0 | 1201.7 | 197.2 | 14.1 | 1.0 |
| 1977 | 25.4 | 364.9 | sum X*Y | 717432.9 | 645.2 | 133147.8 | 9268.3 | 585.3 | -220.4 | -60.4 | -16.6 |
| 1978 | 38.3 | 978.0 | Beta-est | 21.0 | 1466.9 | 956406.0 | 37455.9 | 855.8 | 122.2 | 12.5 | 1.3 |
| 1979 | 39.7 | 659.3 | Alpha-est | 52.7 | 1576.1 | 434722.3 | 26175.6 | 885.1 | -225.8 | -34.2 | -5.2 |
| 1980 | 27.0 | 487.2 | Reg SS | 3156910.7 | 729.0 | 237370.1 | 13154.6 | 618.8 | -131.6 | -27.0 | -5.5 |
| 1981 | 18.3 | 445.7 | Total SS | 3476470.3 | 334.9 | 198616.1 | 8155.6 | 436.4 | 9.2 | 2.1 | 0.5 |
| 1982 | 16.3 | 519.8 | Res MS | 22825.7 | 265.7 | 270191.8 | 8472.7 | 394.5 | 125.3 | 24.1 | 4.6 |
| 1983 | | | R^2 | 0.91 | 0.0 | 0.0 | 0.0 | 52.7 | -52.7 | ERR | ERR |
| 1984 | 8.5 | 299.7 | S | 151.1 | 72.3 | 89840.4 | 2547.7 | 230.9 | 68.8 | 22.9 | 7.7 |
| 1985 | 12.3 | 339.0 | | | 151.3 | 114906.7 | 4169.4 | 310.6 | 28.4 | 8.4 | 2.5 |
| 1986 | 33.6 | 959.8 | calculated y for x= | | 1129.0 | 921256.3 | 32250.0 | 757.2 | 202.6 | 21.1 | 2.2 |
| | | | 13.30 | | | | | | | | |
| | | | 331.59 | | | | | | | | |

REGR 4 :Oregon hatchery, Bonneville Dam, Willamette Falls jacks adjusted for delayed release; all years 1970-86, but 1983

| year | ind varble | dep varble | | | X^2 | | Y^2 | X*Y | Expect Values | Devia tion | % Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 72.1 | 1731.1 | count | 16 | 5198.4 | 2996783.3 | 124813.9 | 1546.7 | 184.4 | 10.7 | 0.6 |
| 1971 | 83.1 | 1680.6 | mean X | 41.6 | 6905.6 | 2824302.4 | 139655.0 | 1784.3 | -103.7 | -6.2 | -0.4 |
| 1972 | 50.7 | 936.4 | mean Y | 888.6 | 2570.5 | 876933.3 | 47477.9 | 1084.6 | -148.2 | -15.8 | -1.7 |
| 1973 | 54.1 | 1175.4 | sum X | 666.0 | 2926.8 | 1381536.5 | 63588.5 | 1158.0 | 17.4 | 1.5 | 0.1 |
| 1974 | 63.3 | 1440.8 | sum Y | 14218.3 | 4006.9 | 2075785.4 | 91200.0 | 1356.7 | 84.1 | 5.8 | 0.4 |
| 1975 | 40.4 | 801.7 | sumX^2 | 34452.0 | 1632.2 | 642725.5 | 32388.7 | 862.2 | -60.5 | -7.5 | -0.9 |
| 1976 | 54.8 | 1398.9 | sumY^2 | 16111406.5 | 3003.0 | 1956882.6 | 76659.0 | 1173.2 | 225.7 | 16.1 | 1.2 |
| 1977 | 25.4 | 364.9 | sum X*Y | 737160.9 | 645.2 | 133147.8 | 9268.3 | 538.3 | -173.4 | -47.5 | -13.0 |
| 1978 | 38.3 | 978.0 | Beta-est | 21.6 | 1466.9 | 956406.0 | 37455.9 | 816.8 | 161.1 | 16.5 | 1.7 |
| 1979 | 40.4 | 659.3 | Alpha-est | -10.2 | 1632.2 | 434722.3 | 26637.1 | 862.2 | -202.9 | -30.8 | -4.7 |
| 1980 | 36.0 | 487.2 | Reg SS | 3138259.8 | 1296.0 | 237370.1 | 17539.4 | 767.2 | -280.0 | -57.5 | -11.8 |
| 1981 | 20.8 | 445.7 | Total SS | 3476470.3 | 432.6 | 198616.1 | 9269.8 | 438.9 | 6.7 | 1.5 | 0.3 |
| 1982 | 19.8 | 519.8 | Res MS | 24157.9 | 392.0 | 270191.8 | 10292.0 | 417.3 | 102.5 | 19.7 | 3.8 |
| 1983 | | | R^2 | 0.90 | 0.0 | 0.0 | 0.0 | -10.2 | 10.2 | ERR | ERR |
| 1984 | 8.9 | 299.7 | S | 155.4 | 79.2 | 89840.4 | 2667.6 | 182.0 | 117.8 | 39.3 | 13.1 |
| 1985 | 11.8 | 339.0 | | | 139.2 | 114906.7 | 4000.0 | 244.6 | 94.4 | 27.8 | 8.2 |
| 1986 | 46.1 | 959.8 | calculated y for x= | | 2125.2 | 921256.3 | 44247.7 | 985.3 | -25.5 | -2.7 | -0.3 |
| | 29.0 | | 29.00 | | | | | | | | |
| | | | 616.0 | | | | | | | | |

REGR 5 : Cowlitz plus Lewis jacks unadjusted for delayed release; odd years 1971-85, but 1983

| year | ind varble | dep varble |
|---|---|---|
| 1970 | | |
| 1971 | 68.5 | 561.4 |
| 1972 | | |
| 1973 | 20.6 | 265.0 |
| 1974 | | |
| 1975 | 26.3 | 382.2 |
| 1976 | | |
| 1977 | 18.0 | 257.9 |
| 1978 | | |
| 1979 | 16.8 | 317.2 |
| 1980 | | |
| 1981 | 17.4 | 305.3 |
| 1982 | | |
| 1983 | | |
| 1984 | | |
| 1985 | 5.0 | 216.0 |
| 1986 | | |

| | |
|---|---|
| count | 7 |
| mean X | 24.7 |
| mean Y | 329.3 |
| sum X | 172.6 |
| sum Y | 2304.9 |
| sumX^2 | 6742.3 |
| sumY^2 | 838386.7 |
| sum X*Y | 70326.8 |
| Beta-est | 5.4 |
| Alpha-est | 195.5 |
| Reg SS | 73231.1 |
| Total SS | 79434.9 |
| Res MS | 1240.8 |
| R^2 | 0.92 |
| S | 35.2 |

calculated y for x=
9.1
244.8

| X^2 | | Y^2 | X*Y | Expect Values | Deviation | % Dev |
|---|---|---|---|---|---|---|
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 4692.3 | 315132.3 | 38453.6 | 567.2 | -5.8 | -1.0 | -0.2 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 424.4 | 70238.5 | 5459.5 | 307.3 | -42.2 | -15.9 | -6.0 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 691.7 | 146041.7 | 10050.7 | 338.2 | 44.0 | 11.5 | 3.0 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 324.0 | 66528.3 | 4642.8 | 293.1 | -35.2 | -13.7 | -5.3 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 282.2 | 100609.2 | 5328.8 | 286.6 | 30.6 | 9.6 | 3.0 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 302.8 | 93180.7 | 5311.4 | 289.9 | 15.4 | 5.0 | 1.6 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |
| 25.0 | 46656.0 | 1080.0 | 222.6 | -6.6 | -3.1 | -1.4 |
| 0.0 | 0.0 | 0.0 | 195.5 | -195.5 | ERR | ERR |

REGR 6 : Cowlitz plus Lewis jacks adjusted for delayed release; odd years 1971-85, but 1983

| year | ind varble | dep varble |
|---|---|---|
| 1970 | | |
| 1971 | 68.5 | 561.4 |
| 1972 | | |
| 1973 | 20.6 | 265.0 |
| 1974 | | |
| 1975 | 26.3 | 382.2 |
| 1976 | | |
| 1977 | 18.0 | 257.9 |
| 1978 | | |
| 1979 | 23.6 | 317.2 |
| 1980 | | |
| 1981 | 25.1 | 305.3 |
| 1982 | | |
| 1983 | | |
| 1984 | | |
| 1985 | 7.5 | 216.0 |
| 1986 | | |

| | |
|---|---|
| count | 7 |
| mean X | 27.1 |
| mean Y | 329.3 |
| sum X | 189.6 |
| sum Y | 2304.9 |
| sumX^2 | 7375.5 |
| sumY^2 | 838386.7 |
| sum X*Y | 75374.1 |
| Beta-est | 5.8 |
| Alpha-est | 172.8 |
| Reg SS | 74791.7 |
| Total SS | 79434.9 |
| Res MS | 928.6 |
| R^2 | 0.94 |
| S | 30.5 |

calculated y for x=
14.6
257.1

| X^2 | | Y^2 | X*Y | Expect Values | Deviation | % Dev |
|---|---|---|---|---|---|---|
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 4692.3 | 315132.3 | 38453.6 | 568.6 | -7.2 | -1.3 | -0.2 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 424.4 | 70238.5 | 5459.5 | 291.8 | -26.8 | -10.1 | -3.8 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 691.7 | 146041.7 | 10050.7 | 324.7 | 57.4 | 15.0 | 3.9 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 324.0 | 66528.3 | 4642.8 | 276.8 | -18.8 | -7.3 | -2.8 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 557.0 | 100609.2 | 7485.7 | 309.1 | 8.1 | 2.5 | 0.8 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 630.0 | 93180.7 | 7661.9 | 317.8 | -12.5 | -4.1 | -1.3 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |
| 56.3 | 46656.0 | 1620.0 | 216.1 | -0.1 | 0.0 | 0.0 |
| 0.0 | 0.0 | 0.0 | 172.8 | -172.8 | ERR | ERR |

REGR 7 : Cowlitz plus Lewis jacks adjusted for delayed release; all years 1970-86, but 1983

| year | ind varble | dep varble | | | X^2 | | Y^2 | X*Y | Expect Values | Deviation | % Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 52.9 | 440.8 | count | 16 | 2798.4 | 194338.5 | 23320.4 | 682.7 | -241.8 | -54.9 | -12.4 |
| 1971 | 68.5 | 561.4 | mean X | 31.4 | 4692.3 | 315132.3 | 38453.6 | 811.7 | -250.3 | -44.6 | -7.9 |
| 1972 | 37.8 | 354.7 | mean Y | 504.7 | 1428.8 | 125779.8 | 13405.9 | 557.8 | -203.1 | -57.3 | -16.2 |
| 1973 | 20.6 | 265.0 | sum X | 502.0 | 424.4 | 70238.5 | 5459.5 | 415.5 | -150.5 | -56.8 | -21.4 |
| 1974 | 41.8 | 906.1 | sum Y | 8074.5 | 1747.2 | 821067.8 | 37876.1 | 590.9 | 315.2 | 34.8 | 3.8 |
| 1975 | 26.3 | 382.2 | sumX^2 | 22415.7 | 691.7 | 146041.7 | 10050.7 | 462.7 | -80.5 | -21.1 | -5.5 |
| 1976 | 77.1 | 1153.4 | sumY^2 | 5594977.2 | 5944.4 | 1330426.5 | 88930.3 | 882.8 | 270.6 | 23.5 | 2.0 |
| 1977 | 18.0 | 257.9 | sum X*Y | 308464.6 | 324.0 | 66528.3 | 4642.8 | 394.0 | -136.1 | -52.8 | -20.5 |
| 1978 | 49.2 | 532.4 | Beta-est | 8.3 | 2420.6 | 283444.8 | 26193.9 | 652.1 | -119.7 | -22.5 | -4.2 |
| 1979 | 23.6 | 317.2 | Alpha-est | 245.2 | 282.2 | 100609.2 | 5328.8 | 384.1 | -66.9 | -21.1 | -6.7 |
| 1980 | 22.5 | 422.6 | Reg SS | 455915.5 | 249.6 | 178606.2 | 6677.4 | 375.8 | 46.8 | 11.1 | 2.6 |
| 1981 | 25.1 | 305.3 | Total SS | 1520087.8 | 302.8 | 93180.7 | 5311.4 | 389.1 | -83.8 | -27.5 | -9.0 |
| 1982 | 26.5 | 511.3 | Res MS | 76012.3 | 404.0 | 261433.4 | 10277.2 | 411.4 | 99.9 | 19.5 | 3.8 |
| 1983 | | | R^2 | 0.30 | 0.0 | 0.0 | 0.0 | 245.2 | -245.2 | ERR | ERR |
| 1984 | 12.8 | 217.8 | S | 275.7 | 123.2 | 47439.3 | 2417.6 | 337.0 | -119.2 | -54.7 | -25.1 |
| 1985 | 7.5 | 216.0 | | | 25.0 | 46637.6 | 1079.8 | 286.5 | -70.6 | -32.7 | -15.1 |
| 1986 | 96.9 | 1230.5 | calculated y for x= | | 557.0 | 1514072.7 | 29039.2 | 440.4 | 790.1 | 64.2 | 5.2 |
| | | | 14.6 | | | | | | | | |
| | | | 320.4 | | | | | | | | |

REGR 8 : Cowlitz plus Lewis jacks unadjusted for delayed release; all years 1970-86, but 1983

| year | ind varble | dep varble | | | X^2 | | Y^2 | X*Y | Expect Values | Deviation | % Dev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 52.9 | 440.8 | count | 16 | 2798.4 | 194338.5 | 23320.4 | 682.7 | -241.8 | -54.9 | -12.4 |
| 1971 | 68.5 | 561.4 | mean X | 31.4 | 4692.3 | 315132.3 | 38453.6 | 811.7 | -250.3 | -44.6 | -7.9 |
| 1972 | 37.8 | 354.7 | mean Y | 504.7 | 1428.8 | 125779.8 | 13405.9 | 557.8 | -203.1 | -57.3 | -16.2 |
| 1973 | 20.6 | 265.0 | sum X | 502.0 | 424.4 | 70238.5 | 5459.5 | 415.5 | -150.5 | -56.8 | -21.4 |
| 1974 | 41.8 | 906.1 | sum Y | 8074.5 | 1747.2 | 821067.8 | 37876.1 | 590.9 | 315.2 | 34.8 | 3.8 |
| 1975 | 26.3 | 382.2 | sumX^2 | 22415.7 | 691.7 | 146041.7 | 10050.7 | 462.7 | -80.5 | -21.1 | -5.5 |
| 1976 | 77.1 | 1153.4 | sumY^2 | 5594977.2 | 5944.4 | 1330426.5 | 88930.3 | 882.8 | 270.6 | 23.5 | 2.0 |
| 1977 | 18.0 | 257.9 | sum X*Y | 308464.6 | 324.0 | 66528.3 | 4642.8 | 394.0 | -136.1 | -52.8 | -20.5 |
| 1978 | 49.2 | 532.4 | Beta-est | 8.3 | 2420.6 | 283444.8 | 26193.9 | 652.1 | -119.7 | -22.5 | -4.2 |
| 1979 | 16.8 | 317.2 | Alpha-est | 245.2 | 282.2 | 100609.2 | 5328.8 | 384.1 | -66.9 | -21.1 | -6.7 |
| 1980 | 15.8 | 422.6 | Reg SS | 455915.5 | 249.6 | 178606.2 | 6677.4 | 375.8 | 46.8 | 11.1 | 2.6 |
| 1981 | 17.4 | 305.3 | Total SS | 1520087.8 | 302.8 | 93180.7 | 5311.4 | 389.1 | -83.8 | -27.5 | -9.0 |
| 1982 | 20.1 | 511.3 | Res MS | 76012.3 | 404.0 | 261433.4 | 10277.2 | 411.4 | 99.9 | 19.5 | 3.8 |
| 1983 | | | R^2 | 0.30 | 0.0 | 0.0 | 0.0 | 245.2 | -245.2 | ERR | ERR |
| 1984 | 11.1 | 217.8 | S | 275.7 | 123.2 | 47439.3 | 2417.6 | 337.0 | -119.2 | -54.7 | -25.1 |
| 1985 | 5.0 | 216.0 | | | 25.0 | 46637.6 | 1079.8 | 286.5 | -70.6 | -32.7 | -15.1 |
| 1986 | 23.6 | 1230.5 | calculated y for x= | | 557.0 | 1514072.7 | 29039.2 | 440.4 | 790.1 | 64.2 | 5.2 |
| | 9.1 | | 9.1 | | | | | | | | |
| | | | 320.4 | | | | | | | | |

## APPENDIX

Table 1. Adult coho returns to catch and escapement areas, 1970-86.

ADULTS:

| Year | OPI | OPI Ocean | OPI Escape | OCN Escape | OPI+ OCN | OPI+TML+OCN | OPI+TML+OCN Harv. rt. | Total OCN a/ | Late Stk Escape | Total Late a/ | Early Stk Escape | Total Early a/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 2794.1 | 1869.2 | 924.9 | 275.7 | 3069.8 | 3084.6 | 0.61 | 699.7 | 173.7 | 440.8 | 682.1 | 1731.1 |
| 1971 | 3658.1 | 3104.1 | 554.0 | 326.5 | 3984.6 | 4012.6 | 0.77 | 1442.1 | 127.1 | 561.4 | 380.5 | 1680.6 |
| 1972 | 2036.5 | 1748.5 | 288.0 | 137.2 | 2173.7 | 2187.7 | 0.80 | 683.4 | 71.2 | 354.7 | 188.0 | 936.4 |
| 1973 | 1994.6 | 1679.5 | 315.1 | 163.4 | 2158.0 | 2171.0 | 0.77 | 721.8 | 60.0 | 265.0 | 266.1 | 1175.4 |
| 1974 | 3128.5 | 2632.1 | 496.4 | 143.9 | 3272.4 | 3276.9 | 0.80 | 731.3 | 178.3 | 906.1 | 283.5 | 1440.8 |
| 1975 | 1768.2 | 1469.4 | 298.8 | 171.3 | 1939.5 | 1942.0 | 0.76 | 703.9 | 93.0 | 382.2 | 195.1 | 801.7 |
| 1976 | 4113.5 | 3727.4 | 386.1 | 181.3 | 4294.8 | 4298.3 | 0.87 | 1365.0 | 153.2 | 1153.4 | 185.8 | 1398.9 |
| 1977 | 1122.6 | 1025.3 | 97.3 | 76.4 | 1199.0 | 1203.0 | 0.85 | 517.2 | 38.1 | 257.9 | 53.9 | 364.9 |
| 1978 | 1850.6 | 1543.1 | 307.5 | 79.0 | 1929.6 | 1932.6 | 0.80 | 392.0 | 107.3 | 532.4 | 197.1 | 978.0 |
| 1979 | 1567.8 | 1261.8 | 306.0 | 173.7 | 1741.5 | 1744.0 | 0.72 | 628.2 | 87.7 | 317.2 | 182.3 | 659.3 |
| 1980 | 1254.7 | 930.5 | 324.2 | 113.8 | 1368.5 | 1372.5 | 0.68 | 353.4 | 136.1 | 422.6 | 156.9 | 487.2 |
| 1981 | 1170.8 | 974.8 | 196.0 | 82.6 | 1253.4 | 1257.9 | 0.77 | 367.0 | 68.7 | 305.3 | 100.3 | 445.7 |
| 1982 | 1312.9 | 841.4 | 471.5 | 143.3 | 1456.2 | 1460.3 | 0.58 | 338.1 | 216.7 | 511.3 | 220.3 | 519.8 |
| 1983 | 666.7 | 551.5 | 115.2 | 64.0 | 730.7 | 733.2 | 0.75 | 258.3 | 54.7 | 220.7 | 41.0 | 165.4 |
| 1984 | 668.1 | 225.3 | 442.8 | 217.4 | 885.5 | 890.5 | 0.25 | 291.0 | 162.7 | 217.8 | 223.9 | 299.7 |
| 1985 | 730.3 | 341.6 | 388.7 | 200.7 | 931.0 | 935.5 | 0.37 | 316.1 | 137.1 | 216.0 | 215.2 | 339.0 |
| 1986 | 2356.0 | 787.5 | 1568.5 | 182.8 | 2538.8 | 2544.8 | 0.31 | 264.7 | 849.7 | 1230.5 | 662.8 | 959.8 |

a/ Escapement/(1-H.R.). Other and somewhat lower estimates (5-20%) have been presented elsewhere: these OCN values calculated for consistency with total early and late stock size estimating methods.

Table 2. Jack coho returns of Columbia River early and late stock, 1969-86.

JACKS a/

| Year | Cowl+Lew (adj.) b/ | Cowl+Lew (unadj.) b | Earlies (adj) c/ | Earlies (unadj.) c/ | ORH+WFLS (adj.) | ORH+WFLS (unadj.) |
|---|---|---|---|---|---|---|
| 1969 | 52.9 | 52.9 | 72.1 | 72.1 | 46.9 | 46.9 |
| 1970 | 68.5 | 68.5 | 83.1 | 83.1 | 57.9 | 57.9 |
| 1971 | 37.8 | 37.8 | 50.7 | 50.7 | 28.5 | 28.5 |
| 1972 | 20.6 | 20.6 | 54.1 | 54.1 | 22.4 | 22.4 |
| 1973 | 41.8 | 41.8 | 63.3 | 63.3 | 34.5 | 34.5 |
| 1974 | 26.3 | 26.3 | 40.4 | 40.4 | 11.1 | 11.1 |
| 1975 | 77.1 | 77.1 | 54.8 | 54.8 | 29.3 | 29.3 |
| 1976 | 18.0 | 18.0 | 25.4 | 25.4 | 8.9 | 8.9 |
| 1977 | 49.2 | 49.2 | 38.3 | 38.3 | 28.2 | 28.2 |
| 1978 | 23.6 | 16.8 | 40.4 | 39.7 | 17.4 | 17.4 |
| 1979 | 22.5 | 15.8 | 36.0 | 27.0 | 12.9 | 11.3 |
| 1980 | 25.1 | 17.4 | 20.8 | 18.3 | 10.6 | 9.2 |
| 1981 | 26.5 | 20.1 | 19.8 | 16.3 | 9.2 | 7.7 |
| 1982 | 29.4 | 19.2 | 43.0 | 31.2 | 14.6 | 12.2 |
| 1983 | 12.8 | 11.1 | 8.9 | 8.5 | 6.7 | 6.9 |
| 1984 | 7.5 | 5.0 | 11.8 | 12.3 | 7.5 | 8.3 |
| 1985 | 96.9 | 23.6 | 46.1 | 33.6 | 19.8 | 15.4 |
| 1986 | 14.6 | 9.1 | 29.0 | 13.3 | 27.2 | 11.5 |

a/ After reductions for small adults called jacks.
b/ Only includes Lewis jacks above background level.
c/ Comprises Oregon hatchery, Bonneville Dam and Willamette Falls.