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IDENTIFICATION OF WILD COHO SALMON STRAYS IN THE COHO RETURN TO OREGON AQUA FOODS AT YAQUINA BAY IN 1982

by

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ABSTRACT

A sample of 1204 readable scales taken from coho salmon returning to Oregon Aqua Foods at Yaquina Bay in 1982 was examined for the presence of scales from wild coho strays. Two methods used for distinguishing scales of hatchery coho from scales of wild coho were 1) age analysis, whereby all scales from returning cohos which were released as age 0 smolts were assumed to be from hatchery fish; and 2) discriminant function analysis to estimate relative numbers of hatchery and wild fish among yearlings in the sample. Classification accuracy was undetermined for age analysis and was calculated to be 98% correct decisions using discriminant function analysis. Estimated stock composition of the 1204 readable scales in the sample was 954 (79.2%) age 0 hatchery coho, 221 (18.4%) yearling hatchery coho, and 29 (2.3%) wild coho. Estimated stock composition of the total return of 47,024 untagged coho to OAF-Yaquina in 1982 was 37,243 age 0 hatchery fish, 8,652 yearling hatchery fish, and 1,129 wild fish.

ACKNOWLEDGMENTS

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1.0 INTRODUCTION

The introduction of commercial salmon ranching facilities at several sites along the coast of Oregon has raised a number of questions concerning the impact of these operations on the production dynamics of resident wild salmon stocks. A particular concern is the incidence of straying between hatchery and wild populations. Straying in both directions is known to occur; hatchery fish may wander onto natural stream spawning areas, and wild fish may ascend fish ladders of salmon ranching facilities. It has been deemed necessary, therefore, to document the rate of straying of stocks between areas. This report is directed specifically at measuring the recovery of wild stock coho salmon at the Oregon Aqua Foods (OAF) release site on Yaquina Bay during the 1982 coho run.

2.0 METHODS

Previous studies by the Oregon Department of Fish and Wildlife (ODFW) have shown discriminant function analysis to be an appropriate tool for distinguishing hatchery and wild fish on the basis of their scale patterns. Numerical and linear measurements of specific scale characters may be processed by a pattern recognition technique such as discriminant function analysis to elucidate underlying stock-specific features of scale patterns. The power of the technique is dependent on the distinctiveness of the pattern types being classified. A key element of this distinctiveness is the variability associated with each type of pattern in the analysis. Classification accuracy increases as variability in stock-specific scale features decreases. Assuming that scale patterns reflect the growth histories of individual fish, the appropriate classification format is to define the discriminant analysis in terms of the growth history types known to be present in samples of scales.

This procedure was considered to be essential to the stock separation program reported here. Based on OAF release reports, the 1982 return of adult coho included fish released as accelerated age 0 smolts as well as some released as "grade-out" yearlings and "programmed" yearlings. All wild fish were presumed to be yearling smolts at seaward migration. Major differences in scale patterns were expected to be found in the portion of scales formed prior to seaward migration of smolts. A simple two-class separation would require that all hatchery scales be pooled into a composite scale pattern type. Previous experience suggested that hatchery yearling scales more closely resemble wild yearling scales than they do hatchery age 0 scales, therefore, the classification power of a discriminant function using a composite hatchery scale type would be significantly reduced. Further, the classification could be biased toward misclassifying hatchery yearling scales as wild yearling scales.

We anticipated that several growth history types probably would be evident in the scale patterns of returning adult coho. Therefore, we initially defined the following 4 classes:

1. Hatchery accelerated - fish released by OAF which were reared on an accelerated growth schedule to be released as zero-age smolts.

2. "Grade-out" yearlings - fish initially reared on an accelerated growth schedule which failed to reach smolt size by late summer and were overwintered.

3. Programmed yearlings - fish reared on a yearling growth schedule.

4. Wild stock - fish that reared at liberty in streams within the Yaquina River watershed prior to seaward migration as smolts.

Past experience with scales from OAF coho indicated that the patterns on scales of age 0 and yearling fish are markedly distinctive and easily distinguishable by eye. Under the assumption that no wild fish migrated to sea as age 0 smolts, we used age designation as the initial classification step. This procedure reduced the number of scales to be measured for discriminant function analysis by about 80%.

Remaining yearling scales were processed using a methodology developed for separating stocks of sockeye salmon that mix in an Alaska seine fishery. Measurement and analysis of scale patterns is semi-computerized in this method, and it has proved to be efficient and reliable in field and laboratory applications. The elements of the procedure are given below.

2.1 Scale Collection

Scales used in this study were sampled under the direction of ODFW[1]. Standard samples were obtained as follows:

1. Wild standard - A sample of 103 scales taken from fish on natural spawning grounds in coastal watersheds during 1980-82 was designated as the wild stock standard. Upon visual examination of the scales, those from the Alsea system were found to be grossly dissimilar from those taken in the Yaquina system. Consequently, scales not sampled within the Yaquina watershed (n = 9) were excluded from the wild standard. An additional 3 scales of poor quality were not measured, leaving 89 scales in the wild standard sample.

2. Hatchery yearling standard - Scales from coho in the OAF harvest identified by coded-wire tag as yearling adults were provided by OAF on gum cards with corresponding rearing history data. Insufficient numbers of "grade-out" yearling scales were available to form a separate standard, so all hatchery yearling scales were pooled into the single standard. Sample size was set at 98 to be roughly equal to the wild standard sample size.

Scales from fish of unknown stock were sampled at the rate of about 4% of weekly returns of untagged adult coho at OAF-Yaquina. This level of sampling effort was designed by ODFW to provide a 95% confidence interval $\pm$ 25% of the point estimate of the number of wild adult coho in the OAF return. Of 1735 scales received, 511 were judged to be unuseable for discriminant analysis, leaving a total of 1204 scales in the unknown sample.

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[1]Scales were selected only from the preferred area (Clutter and Whitesel 1956) of each fish sampled.

2.2 Scale Measurement

An overview of the microcomputer-controlled digitizing system at the Fisheries Research Institute is shown in Figure 1. This system is used to record, store, and edit raw data. Biological data accompanying each measured scale is compiled on a pre-formatted CRT display along with other identifiers. Scale images projected at 210X onto the surface of an electronic digitizer are measured with a precision of 0.01" by moving a hand-held cursor across the projected image. A FORTRAN computer program controls data capture.

All scales from wild and hatchery yearling standards and from yearlings in the unknown sample were processed on the digitizer. Scale images were oriented on the digitizing screen such that a pre-selected radius passed through the longest axis of the scale. Measurements were initialized at the proximal edge of the first circulus of scale growth to eliminate ambiguity in choosing the center of each scale focus. No attempt was made to identify annuli or partition measurements into first and second year scale growth, as identification of annuli was ambiguous on some scales. Numbers and inter-increment distances of circuli in the pre-release zone (or freshwater zone for wild scales) were stored on floppy discs in the microprocessor until transfer to a mainframe computer.

2.3 Analysis

Raw scale data for each stock were transformed by FORTRAN program into the following scale characters:

1. NCIRC - number of circuli in pre-release or freshwater zone of scale;
2. TOTSZ - distance from scale focus to end of pre-release or freshwater scale growth;
3. TRIP1 - distance from focus to circulus 3;
4. TRIP2 - distance between circuli 3-6;
5. TRIP3 - distance between circuli 6-9;
6. TRIP4 - distance between circuli 7-12;
7. TRIP5 - distance between circuli 12-15.

These variables were entered into a pre-programmed linear discriminant function (BMDP7M) to generate the discriminant rule. The BMDP series program was chosen for its features of stepwise character selection and the jackknifing procedure for estimating classification accuracy. The jackknife feature is particularly desirable when standard sample size falls below approximately 200. Stepwise character selection is useful to the investigator for controlling the inclusion of variables to the fewest that significantly improve classification accuracy.

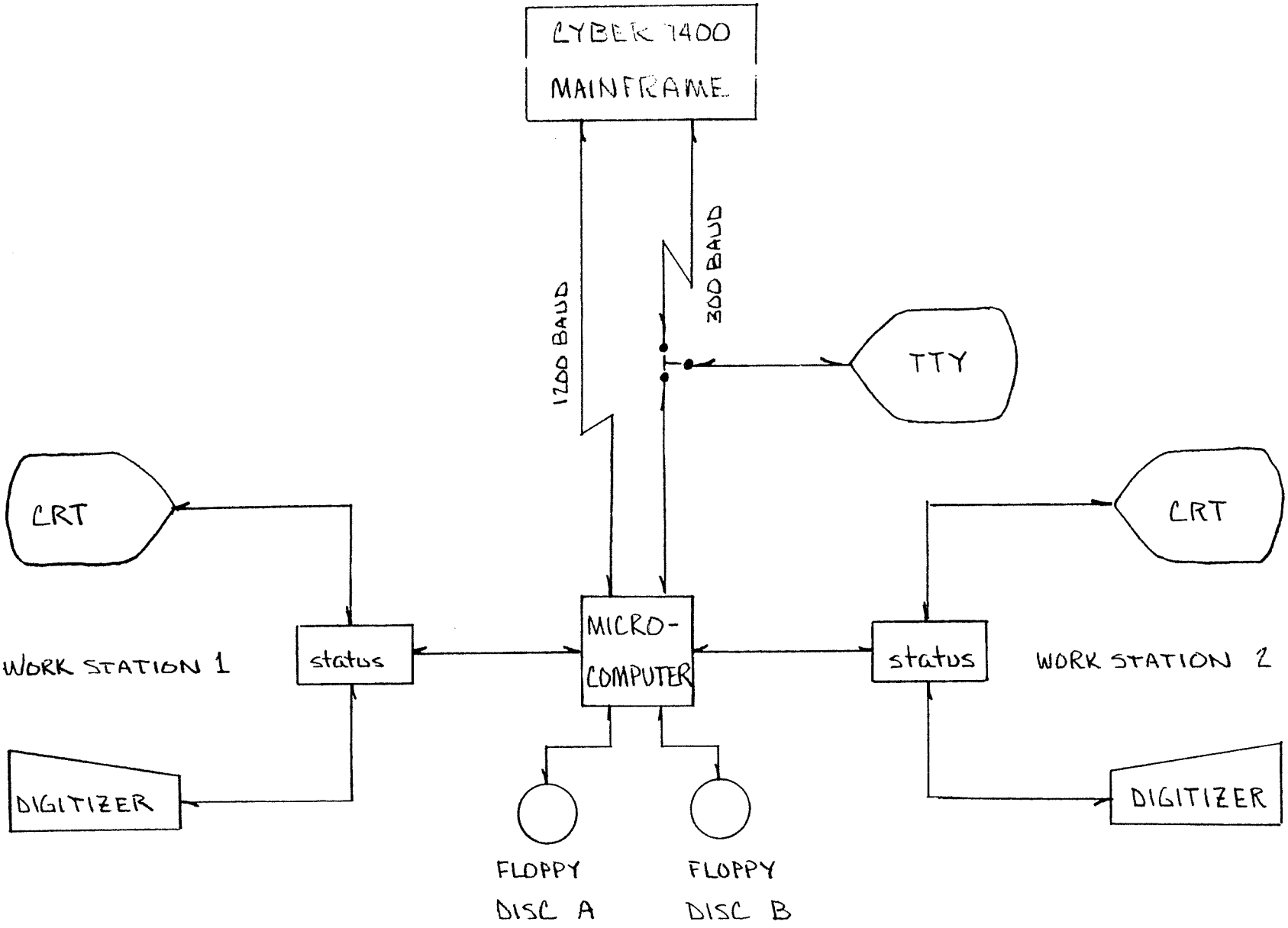

Fig. 1. Overview of the microcomputer-based scale digitizing system at the Fisheries Research Institute, University of Washington.

2.4 Interpretation and Conclusions

Results were treated as a three-class separation problem in which age 0 coho, hatchery yearlings, and wild yearlings constituted separate classes. Point estimates of the numbers of each stock present in the unknown sample were obtained by age analysis in the case of age 0 coho, and by discriminant function analysis in the case of hatchery and wild yearlings. Confidence intervals were calculated only for point estimates of numbers of hatchery and wild yearlings because no variance estimate was available for the visual classification of age 0 hatchery cohos. 95% confidence limits were calculated as:

$$N_i \pm 1.96 \quad \text{Var}\,(N_i)$$

where N_i = number of fish in stock i

and $\text{Var}(N_i) = N^2\,(\text{Var}\,P_i)$

$P_i = N_{i/N}$

N = size of the sample.

3.0 RESULTS AND DISCUSSION

3.1 Age Composition

Analysis of the 1204 useable scales in the unknown sample revealed that 954 (79.2%) were age 0 coho and 250 (20.8%) were yearlings. Although we did not compute an estimate of classification error rate for this step, it is assumed that misclassification of age 0 scales was negligible.

3.2 Discriminant Function Analysis

3.2.1 Classification Accuracy

The results of stepwise variable selection (Table 1) showed that increasing the number of variables above two was not warranted. We therefore used the number of circuli in the pre-release or freshwater scale zone and the distance between circuli 3-6 to classify fish of unknown origin sampled from the population of untagged coho returning to OAF-Yaquina. The classification matrix for the two-group discriminant analysis was calculated using hatchery and wild standards (Table 2). Overall classification accuracy was estimated at 98.0% using this set of data. Note that approximately 4% of the hatchery standard misclassified as wild, while 100% of the wild standard was correctly classified. This suggests that misclassification in the unknown sample was conservative with respect to the detection of wild fish.

The BMDP discriminant function program does not generate a variance estimate based on classification accuracy. The variance for stock composition estimates was obtained through a modified version of program CLASS (Conrad and Burgner 1981), operating on a Vector Graphics microprocessor. The variance on the estimate of relative proportions of each stock was 0.00082.

3.2.2 Stock Composition of Yearling Subsample

Of the 250 scales classified as yearlings, 221 $\pm$ 14 (88.4 $\pm$ 5.6%) were estimated by discriminant function analysis to be of hatchery origin, and 29 $\pm$ 14 (11.6 $\pm$ 5.6%) were estimated to be of wild origin.

3.3 Stock Composition of Unknown Sample

A summary of classification of the 1204 coho scales in the unknown sample is given in Table 3. The unknown sample was composed of 954 (79.2%) age 0 hatchery scales, 221 (18.4%) yearling hatchery scales, and 29 (2.4%) wild scales. Use of separate classification techniques and the absence of a variance estimate for the visual discrimination of age 0 scales from yearling scales precluded calculation of 95% confidence limits for the estimate of the pooled number of age 0 and yearling hatchery scales in the unknown sample.

Table 1. Classification accuracy as a function of variables used.

Number of variables	Variable code number[1]	Percent correctly classified[2]
1	1	91.1
2	1, 4	98.0
3	1, 4, 5	96.4
4	1, 4, 5, 3	97.4
5	1, 4, 5, 3, 2	97.4
6	1, 4, 5, 3, 2, 6	98.4

[1]Variable codes: 1 = number of circuli in pre-release or freshwater zone
2 = distance from focus to end of pre-release or freshwater zone
3 = distance from focus to circulus 3
4 = distance between circuli 3-6
5 = distance between circuli 6-9
6 = distance between circuli 9-12

[2]Based on training samples.

Table 2. Jackknifed classification matrix for yearling hatchery and wild training samples.

Stock	Percent correct decisions	Number of cases classified into group	
		Hatchery	Wild
Hatchery	95.9	93	4
Wild	100.0	0	89
Total	98.0	93	93

Table 3. Stock composition estimates and confidence intervals for the sample of 1204 scales taken from the OAF-Yaquina coho harvest in 1982.

Stock	Method of separation	Point estimate	Variance	95% confidence interval
Age 0 hatchery	Visual discrimination	954 (79.2%)	None computed	--
Hatchery yearling	Discriminant function analysis	221 (18.4%)	0.00082	207-235 (17.2-19.5%)
Wild yearling	Discriminant function analysis	29 (2.4%)	0.00082	15-43 (1.2-3.6%)

Total sample size = 1204

3.4 Stock Composition of Total Coho Return

The total return of coho salmon to OAF-Yaquina in 1982 was 53,819 of which 6,795 were tagged fish of all ages and 47,024 were untagged fish of all ages (Cummings, personal communication). Expansion of sample estimates to the untagged component of the total coho return suggests that 37,243 were age 0 hatchery fish, 8,652 (8,088-9,170) were yearling hatchery fish, and 1,129 (564-1693) were wild fish (Table 4).

Table 4. Final estimates of the numbers of hatchery and wild cohos in the total return of untagged fish to OAF-Yaquina in 1982.

Stock	Point estimate	95% confidence interval
Age 0 hatchery	37,243	none computed
Yearling hatchery	8,652	8,088 - 9,170
Wild	1,129	564 - 1,693

4.0 SUMMARY OF CONCLUSIONS

1. A sample of 1204 readable scales taken from coho salmon returning to Oregon Aqua Foods at Yaquina Bay in 1982 was examined for the presence of scales from wild coho strays.

2. Two methods used for distinguishing scales of hatchery coho from scales of wild coho were:

   A. Age analysis, whereby all scales from returning cohos which were released as age 0 smolts were classified as hatchery fish.

   B. Discriminant function analysis of all yearling scales in the sample to estimate relative numbers of hatchery and wild fish in the yearling subsample.

3. Classification accuracy was undetermined for age analysis and was estimated to be 98.0% correct decisions using discriminant function analysis.

4. Estimated stock composition of the 1204 readable scales in the sample was 954 (79.2%) age 0 hatchery coho, 221 (18.4%) yearling hatchery coho, and 29 (2.4%) wild coho.

5. Estimated stock composition of the total return of 47,024 untagged coho to OAF-Yaquina in 1982 was 37,243 age 0 hatchery fish, 8,652 yearling hatchery fish, and 1,129 wild fish.

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