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OPTIMAL SIZE AND TIME FOR RELEASE
OF COHO SALMON SMOLTS INTO YAQUINA BAY, OREGON

by

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Contract Completion Report to
Oregon Aqua Foods, Inc.

Approved

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ABSTRACT

The size at which coho smolts are released from saltwater acclimation ponds into Yaquina Bay greatly affects the probability of their survival to adulthood. Comparisons of length frequency distributions for CWT smolt groups released in May-September 1980 against distributions of length at release back-calculated from scales of adults from each of the same CWT groups returning in 1981 indicates that:

1. Definite boundaries exist on the range of smolt sizes that produce profitable returns of adults.

2. The optimum size at release for coho smolts varies as a function of time of release.

ACKNOWLEDGMENTS

Robert Thomsen, Information Systems Coordinator for Oregon Aqua-Foods, Inc., provided a sorted list of CWT data from the 1981 coho return to Yaquina Bay, which substantially reduced the time spent assembling samples of adult scales from each smolt release group. Drs. Loveday Conquest, Steven Mathews, and Terrence Quinn III provided statistical advice.

1.0 INTRODUCTION

The goal of ocean ranching enterprises is to maximize the return from each investment of salmon smolts released into the ocean. The profitability of any such investment is measured in the amount of marketable salmon that returns to the point of release. The biomass of adult returns is a function of both the numbers of smolts released and their survival in the ocean. Since the number of smolts that can be released by any single ocean rancher presently is limited by state regulations, a major increase in the biomass of marketable adult salmon is possible only by increasing the survival of juveniles during ocean residence. It is of primary importance to ocean ranchers, therefore, to understand factors limiting ocean survival and to develop aquaculture techniques that produce high quality smolts. High quality here refers to a smolt that has the greatest potential to produce an adult. One criterion of smolt quality as used in this context is size at release into the ocean.

Size at seaward migration has been positively correlated with survival to adulthood in a number of studies on natural (Burgner 1962) and hatchery (Wallis 1968; Hager and Noble 1976; Bilton 1978) smolt populations. These generally have taken the form of factorial experiments in size and time of release of marked or tagged hatchery fish, or comparisons of mean body size for a yearclass of smolts at outmigration against the mean for smolts of the yearclass that survive to adulthood. The latter type of study on natural populations uses the growth history record encoded in scale patterns to estimate the size at which returning adults migrated to sea. Allometric relationships between fish size and scale size are calibrated with data taken from samples of smolts and used to back-calculate size at outmigration from measurements of the patterns on adult scales corresponding to seaward migration.

We believe that scale pattern analysis is preferable in many cases to a factorial experiment, and in any case is a valuable supplement to factorial designs of smolt release strategies. It is our contention that scale pattern analysis produces a great deal of information about within-group size variation and differential survival that factorial analyses are not designed to elucidate. Conventional factorial experiments report differences in survival between smolt groups in terms of differences in the mean size of fish released in the groups, whereas scale analysis presents this information against a background distribution of smolt sizes within each group. This additional resolution permits an investigator to identify the size classes within each release group that contribute most to the production of adults.

Parker et al. (1981) reported that the back-calculation of length at release for coho salmon adults returning in 1980 was a feasible means for examining size-dependent survival of smolts released into Yaquina Bay. The lack of essential baseline data precluded a clear demonstration of size-dependent survival in that study; nevertheless, necessary analytical tools, such as a fish length-scale radius relationship for

OAF cohos, were shown to be functionally adequate for a more exhaustive study.

Herein we report the results of a study on optimal size and time for coho smolt releases into Yaquina Bay. Size is given in units of fish length because the back-calculation of length from scale measurements is considerably more precise than the back-calculation of weight (Parker et al. 1981). Weight equivalents are, however, shown in parentheses to facilitate the incorporation of size recommendations into hatchery production schedules (see Appendix Table 1 for length-weight transformations). The primary objective was to identify the size classes within smolt groups released monthly from June through September that exhibited the maximum rate of return per smolt investment. Demonstration of size-dependent survival within release groups was presented as a simple test of hypotheses:

H_O: The mean size at release of smolts surviving to return as adults to the hatchery was not significantly different from the mean of the smolt group at release;

H_A: The mean size of smolts which survived to return as adults to the hatchery was significantly larger than the mean of the smolt group at release.

Two a priori assumptions enabled us to draw conclusions from the results. The hypothesis test described above requires that length data are distributed normally with parameters μ and δ^2. Since most such population data has been shown to conform to the normal distribution, we were comfortable with this assumption. The second assumption is less defensible but, at present, no more objectionable. We postulated that the ocean troll harvest of cohos was not selective of any release group nor any size at release within release groups. In the absence of summarized CWT data, it is currently impossible to confirm or reject this presumption; nevertheless, its validity could alter our usage of "survival" as being equivalent to return to hatchery racks.

2.0 MATERIALS AND METHODS

2.1 Scale Preparation

Scales used in this study were sampled from production lots of coho salmon identified by coded wire tag implants. CWT groups having identical rearing histories were catalogued into larger ID groups to increase sample sizes of smolt and adult scales. This arrangement is summarized in Table 1. Scales removed from smolts 1 day prior to release from saltwater acclimation ponds at the Yaquina Bay release site were received as scale smears accompanied by individual lengths, weights, date of sample, and production group identity. Each scale smear was examined under a binocular microscope and the "best" four scales were dry-mounted between microscope slides. Scales selected for measurement were judged to be the largest (first formed) that showed no regeneration in the nuclear region. Scales sampled from adults were affixed to gummed paper tape cards and identified by date of sample and tag code. These scales were pressed into acetate replicas by the method of Koo (1962).

2.2 Interpretation of Scale Patterns

As in previous studies, we found that the interpretation of patterns in the pre-release zone of age 0 scales can be extremely difficult. False checks, possibly related to vaccination or grading stress, are common (Parker et al. 1981). Our primary concern, therefore, was limited to identifying the circulus or circuli on scales of adults that indicated release from saltwater ponds into the Yaquina Bay estuary. This was complicated by the presence of more than one check near the end of pre-release growth on many adult scales. Reference to hatchery release reports and reexamination of smolt scales from groups released in each month indicated that the first check in this pattern formed upon initial entry into saltwater acclimation ponds at Yaquina Bay, and the second formed at release into the estuary (Fig. 1). The number of circuli between the first and second check varied as a function of time held in saltwater ponds. Circuli formed at approximately weekly intervals during this period. Groups were acclimated for an average of 16 days before release into Yaquina Bay, but this ranged from 10 to 26 days for some groups.

We used this life history information to define an informal scale standard for each release group. Smolt scales from each group were examined at 70x, and the number of circuli from scale focus to first check and to the second check were determined. Confusing patterns on the scales of adult fish were then resolved by reference to the "standard" from the appropriate smolt release group.

2.3 Scale Measurement

Constraints on the availability of the digitizing equipment at FRI precluded its use for this analysis. Instead, a subsample of all adult

Table 1. Summary of scale sample inventory acquired for the scale pattern analysis.

CWT groups	ID groups	N of scales Smolt	N of scales Adult	Date of release
603143	05	24	45	5/1/80
NT; 603145-603154; 603226; 603227, 603230, 603301, 603303-603305; 603308-603310; 603327-603329; 603234	NT=11, CWT=12	46	59	NT=6/20/80 CWT=6/28/80
NT: NT	16, 20	46	46	ID16=7/17/80 ID20=7/27/80
Note: Adult scales from group ID18, released 7/23/80, were used because groups ID16 and ID20 were not tagged. No smolt scale samples were available from ID18.				
603343; 603222, 603223; 603232, 603233; 603260, 603261; 603238, 603239; 603253; 603321; 603307; 603243; 603333; 603207, 603208	603343=23 others=26	48	64	ID23=8/3/80 ID26=8/25/80
NT; 603332;	27	24	51	9/4/80

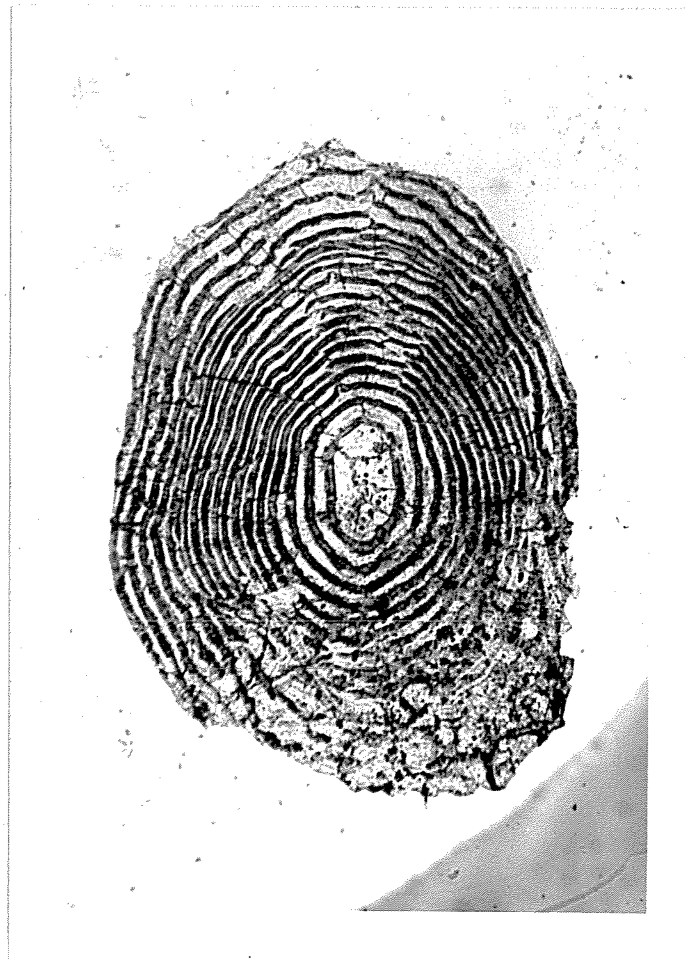

Fig. 1. Smolt scale taken 1 day prior to release into Yaquina Bay. Note the check formed at entry into saltwater acclimation ponds (arrow) and circuli formed prior to release.

scale replicas projected 70x to the screen of a microfiche reader was measured with a millimeter scale enlarged 70x drawn on a clear mylar sheet. Three measurements were made to the nearest 0.1 mm along an axis selected in the manner described in Parker et al. (1981):

1. Distance from focus to outer edge of release check,
2. Distance from focus to first ocean annulus,
3. Distance from focus to scale margin.

We believe that the accuracy of this method was comparable to that achieved with the scale digitizer and, given that only three clearly distinguishable scale features were measured, did not impair the analysis in any way. Furthermore, measurement of scales was appreciably more rapid than with the digitizer. The only drawback in not using the microprocessor-based system was that data base management was somewhat more cumbersome.

2.4 Calculation of Size at Release

Size at release of adults returning to Yaquina Bay in 1981 was estimated from scale measurements. Regressions of smolt length on scale radius were developed for each group released in May to September 1980 from the samples taken at release into Yaquina Bay.

Confidence limits on estimates of fish length were computed as:

$$\hat{Y} \pm t_{(n-2,\ .05)}\ S_{y/x} \sqrt{\frac{1}{n} + \frac{(x_i - \bar{x})^2}{\Sigma(x_i - \bar{x})^2}}$$

where

t = "t" value for 95% confidence, n-2 d.f.

$S_{y/x}$ = standard deviation of y at any value of x

n = sample size.

Regression equations were calculated for each group separately in case differences in the fish growth-scale growth allometry existed. The existence of variability in the relationship between scale size and fish size was tested by analysis of covariance. Based on the results of ANCOVA, we could either average all regression equations and use this single equation to back-calculate length at release from adult scales of any CWT group, or we would use the regression equations specific to each monthly release groups for adult scales from those groups.

2.5 Differential Survival by Size Class

The hypothesis that larger smolts in a release group show higher survival rates was examined by comparing smolt length frequency distributions against distributions of calculated length at release of adults on a group-by-group basis. A significant difference of means in length of the smolt population released and of the population recovered as adults would reject the null hypothesis of no differential survival of a particular size component. Since the incidence of jacks from age 0 OAF smolt releases was extremely low (Parker and Burgner 1981), we felt that the exclusion of jack returns would not measurably affect our results.

We assumed normality in the distribution of length data and used t-tests to determine the significance of differences between mean lengths of the released and recovered smolt populations. We used t-tests of the form

$$t_{(n_1 + n_2 - 2)} = \frac{\bar{Y}_2 - \bar{Y}_1}{\sqrt{Var\bar{Y}_1 + Var\bar{Y}_2}}$$

where $\bar{Y}_1$ = mean length of all smolts released
$\bar{Y}_2$ = mean length of smolts recovered as adults

Because the Y_2 were predicted from the regression of fish length on scale radius, the variance of $\bar{Y}_2$ is a composite of variance in the fish size-scale size allometry and variance in the frequency distribution of the Y_2. The variance of $\bar{Y}_2$ was therefore computed by the "Delta method" (Sokal and Rolf 1969), where

$$Var\bar{Y} = 1/n^2 \ \Sigma \ VarY_i$$

and

$$Var\ Y_i = S^2{}_{y/x}\ (1 + 1/n + \frac{(X_i - \bar{X})^2}{\Sigma(x_i - \bar{x})^2})$$

2.6 Ocean Growth of Juveniles

The growth of post-smolt coho juveniles in their first year at sea was indexed from scale measurements in the following way:

$$\text{Percent first ocean growth} = \frac{\text{first ocean radius}}{\text{total ocean radius}} \times 100$$

where:

first ocean radius = distance from focus to first ocean annulus minus distance from focus to release check

total ocean radius = distance from focus to margin minus distance from focus to release check.

3.0 RESULTS AND DISCUSSION

3.1 Length at Release

Relationships between fish length and scale radius were positive and linear in all groups (Fig. 2a-e). Most of the variability in the relationships probably derives from small sample sizes and sampling error rather than from natural irregularity in allometric growth. Partial correlation analysis suggested that differences in fish weight or condition factor did not contribute significantly to deviation from the fish size-scale size relationship. We attribute much of the uncertainty, therefore, to sampling error associated with inconsistently choosing the preferred scale (Clutter and Whitesel 1956) from within a scale smear. The back-calculation of fish length from scale patterns rests on the assumption that differences in scale measurements reflect differences in fish length. The technique of smear sampling unavoidably presents the investigator with a diversity of scale sizes from which the preferred scale may or may not be subsampled. The regressions shown in Fig. 2a-e therefore measure not only intrinsic variability in the fish size-scale size relationship, but also extrinsic variability added by the choice of scale selected for measurement from among those in a smear. We suggest that in the future, 3-4 scales routinely should be taken from the preferred area on the fish.

Regression analysis of length data on scale radius showed that all regressions were significant, with the exception of yearling release groups (Table 2). Analysis of covariance indicated that regression lines were significantly different, thus the use of a common fish

Table 2. Regression equations used to back-calculate fish length from scale radius measurements for CWT groups released in each of the months indicated.

Month of release	Equation	N of cases	R^2	$S_{y/x}$
May	$\hat{Y} = 148.00 + 0.369x$	24	0.05	12.19
June	$\hat{Y} = 93.55 + 0.65x$	46	0.14	9.96
July	$\hat{Y} = 86.53 + 1.00x$	46	0.35	10.03
August	$\hat{Y} = 73.44 + 1.37x$	48	0.34	11.95
September	$\hat{Y} = 53.60 + 1.94x$	24	0.71	10.98

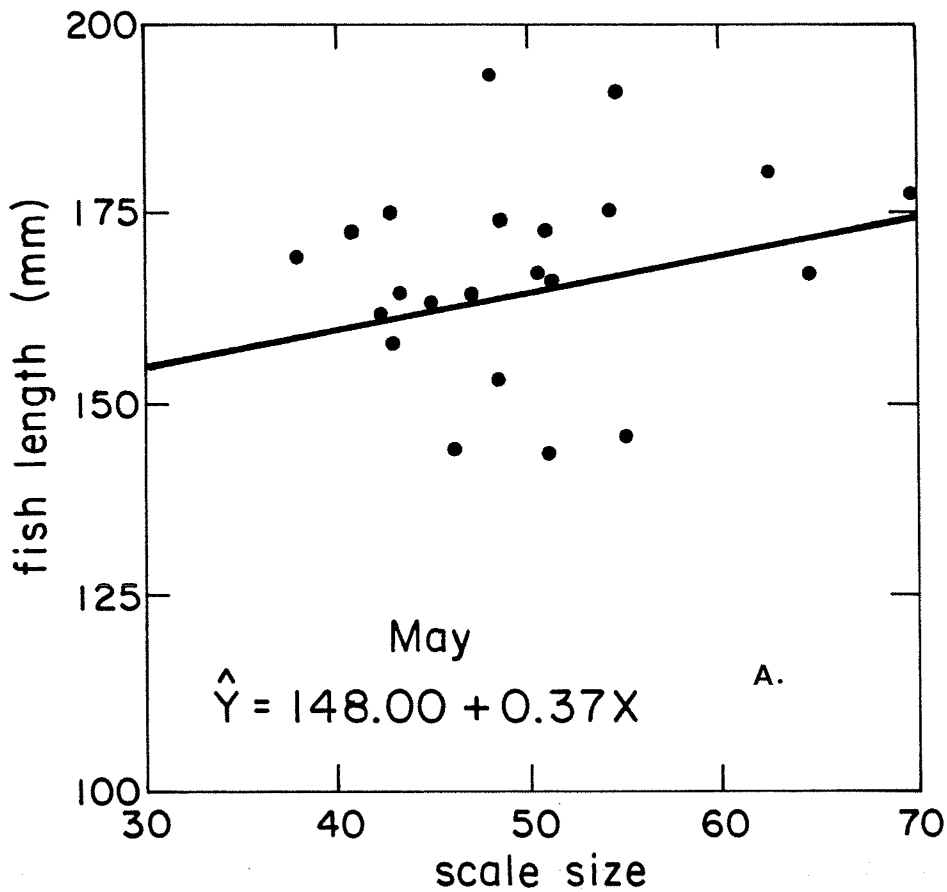

Fig. 2 a-e. Relationships between fish size and scale size for groups released in the months indicated. Regression lines and equations are least-squares fits of the data. Scale size is in measurement units at 70x projection.

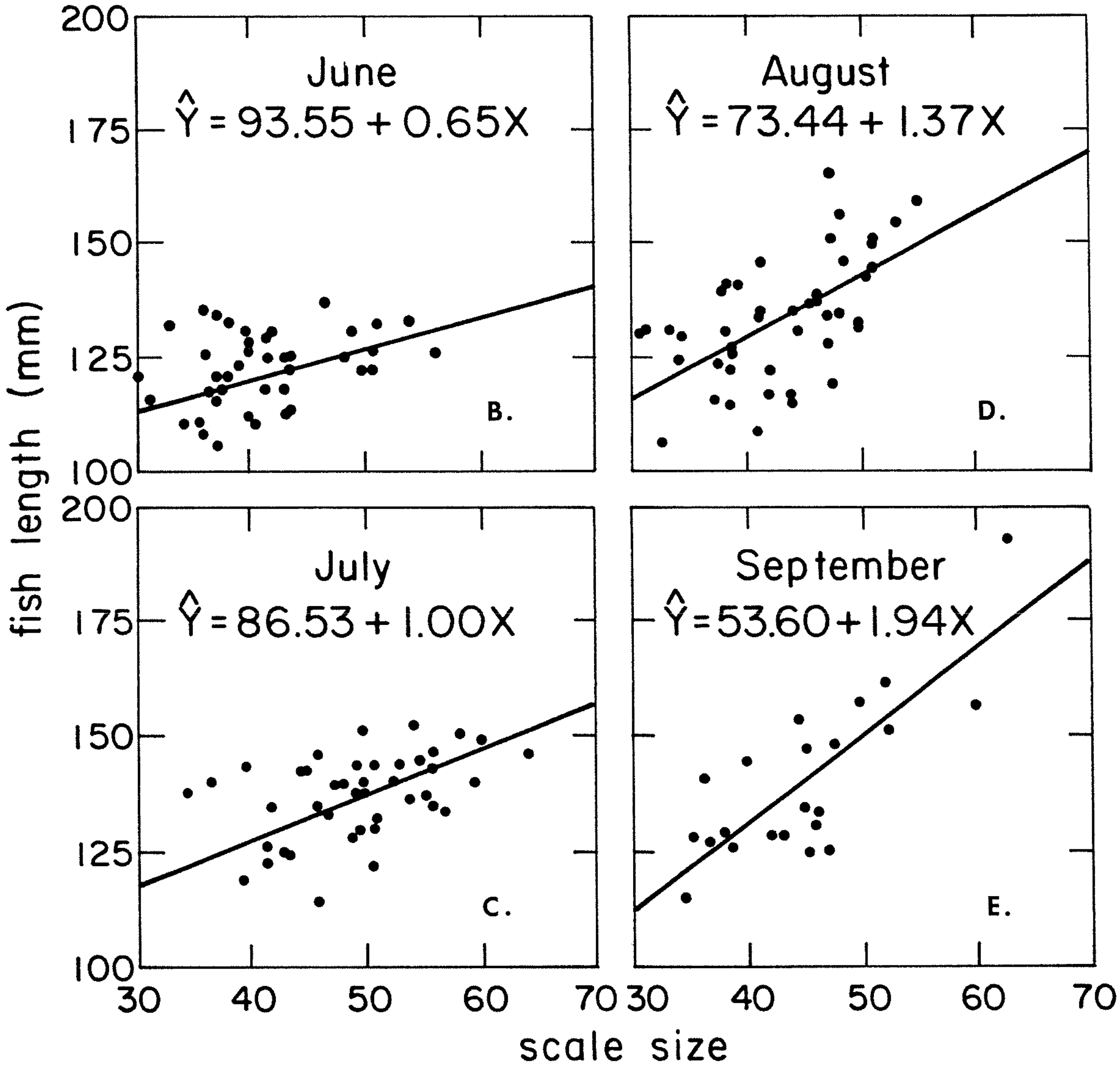

Fig. 2a-e - continued.

length-scale radius linear model was not justified (Table 3). Back-calculations of size at release from adult scale consequently were performed using group-specific models. We were unable to determine why the

Table 3. Analysis of covariance of regression equations used to back-calculate fish length from scale radius.

Source	df	SS	MS	F
Total	164	2,831,304		
CFM	1	2,792,961		
Regression of common line	1	14,788		
Residuals about common line	162	23,555		
Σ residuals about individual lines	156	18,004	115.4	8.02**
Difference	6	5,551	925.2	

**Denotes significance at 0.001 level

fish length-scale radius allometry varied between groups released in different months. Figure 2a-e shows a consistent trend in the regression lines calculated for each month, indicating that in later releases length increased at a faster rate relative to scale size. This may relate to different rearing histories that affect the number of scale buds initially formed on fry, or possibly to genetic differences among release groups. Perhaps a more likely explanation is simply that later release groups had a distinctly higher condition factor, suggesting that a given number of scales had to cover a surface area on fish that grew in length at the same rate as fish released earlier, but increased in weight (and volume) at a much higher rate.

3.2 Size Dependent Survival

Ocean survival expressed in terms of adult returns to the hatchery ignores the possibility that adults from the various CWT groups experience unequal exploitation rates during their exposure to the ocean troll fishery. The effect of differential harvest pressure, if it exists, could significantly alter the interpretation of our results. As we presently have no information suggestive of group-specific migration timing, we assume in this analysis that all CWT groups experience approximately the same fishing mortality.

Table 4 gives mean length at release ± 95% confidence limits for

Table 4. Comparison of population means for length at release of all smolts in release groups against length at release for smolts surviving to return as adults.

Month of release	Mean length at release of smolts (mm) Y_1	Mean length at release of adults (mm) Y_2	Probability that $Y_1 = Y_2$
June	120.2 ± 2.96	124.6 ± 4.47	$P < .02$
July	135.4 ± 2.98	145.8 ± 5.23	$P < .001$
August	131.9 ± 3.47	143.0 ± 5.73	$P < .001$
September	138.0 ± 4.86	155.1 ± 6.34	$P < .001$

each smolt group released in June through September 1980, and for the adults of each of those groups returning in 1981. Length frequency distributions for released and recovered (as adults) smolt populations are presented in Fig. 3a-d. Smolt survival by 5 mm length increment is shown by comparing the percentage of smolts released in each length interval against the percentage of returned adults that were released as smolts in each length interval. These data clearly show two things of particular interest:

1. Approximately 20-40% of all smolt releases were below a minimum size for survival. This represents a large fraction of the investment in smolts that contributed no marketable product. The minimum size threshold varied from 120 mm (20 g) in June to 130-135 mm (25-31 g) in July, August, and September.

2. The mean size at release of smolts that survived to adulthood was significantly larger than the population mean at release for all groups ($p<.02$ for June; $p<.001$ for others).

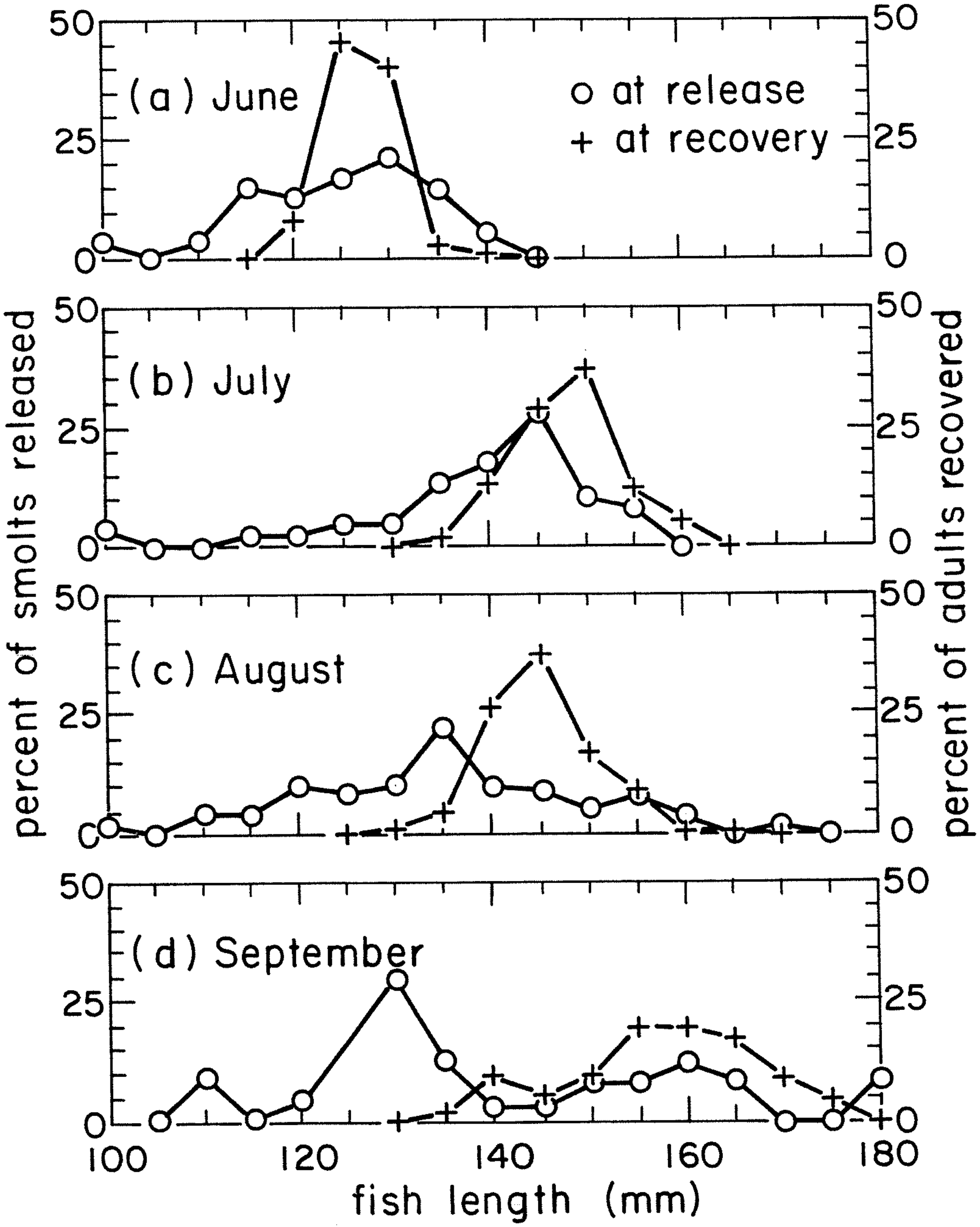

Fig. 3 a-d. Length frequency plots, expressed as the percentage of smolts released and recovered (as adults) in each 5 mm length increment. Size-dependent survival (i.e., return) is indicated by the difference in mean values for each pair of distributions.

Table 5 summarizes the survival of smolts in each length increment by month of release. The following statistics are distilled from the data:

1. No fish in the June sample population smaller than 115 mm (17 g) at release survived to adulthood. This size range contained about 26.1% of the smolt production for June. Approximately 86.5% of the adult return was realized from smolts released at 120-130 mm (20-25 g), or about 39.1% of smolt production. Only 6.1% of the adult return were 130-140 mm (25-31 g) at release, while this size range comprised about 21.7% of the release.

2. Fish released smaller than 130 mm (24.5 g), or about 21.7% of July releases, did not return as adults. Smolts released between 140 mm (31 g) and 150 mm (38 g) accounted for 65.3% of the adult return and 34.2% of releases.

3. Approximately 1.6% of the adult return from August releases was recovered from smolts less than 130 mm in length (28 g). This size range represents 39.6% of the smolts released in August. Over 81% of returning adults were 135-150 mm (38-43 g) at release and were produced from about 25% of the smolt group.

4. No fish less than 130 mm (27 g) at release in September survived to adulthood. Nearly 42% of September smolt production occupied this category. Of the total smolt release, 29.1% between 150 mm (41 g) and 165 mm (55 g) produced 56.8% of the adults that returned.

These results should not be interpreted simply as "bigger is better." Figure 4 is a plot of survival by 5 mm length increment within each smolt release group expressed in terms of the percentage of smolts in each length interval that returned as adults. These curves chart the magnitude of the difference between the two lines plotted in each of Fig. 3a-d as a function of length. It is apparent that an optimum size exists for smolts released in each month. The likelihood of survival at sea declines sharply for smolts smaller or larger than the optimum, with the exception of those released in September for which no clear trend is defined. Furthermore, several studies (Bilton 1978; Hager and Noble 1976; Wallis 1968) have shown that large smolts as a group show a higher tendency to return as jacks, which may be undesireable for both marketing and broodstock purposes.

3.3 Time Dependent Survival

In general, smolts released later in the season showed a higher rate of return than those released earlier. Average survival for groups released in June was 0.36%, with the maximum value of 0.95% obtained for smolts 12.0-12.5 cm at release. July release groups showed an overall

Table 5. Length frequency distributions for released and recovered (as adults) smolt populations by month of release. Size-specific survival rates are calculated as the percentage of smolts in a size class surviving to adult return.

		Total tagged	Length (mm) <115	120	125	130	135	140	145	150	155	160	165	170	>170
June ID12															
Release	N	180,683	47,135	23,567	31,423	39,279	27,495	11,784	0						
	%	100.0	26.1	13.0	17.4	21.7	15.2	6.5	0						
Return	N	652	0	55	298	265	22	11	0						
	%	100.0	0	8.5	45.8	40.7	3.4	1.7	0						
Percent survival		0.361	0	0.23	0.95	0.68	0.08	0.09	0						
July ID16, ID18, ID20															
Release	N	29,986	1,923	755	1,919	1,921	3,911	5,215	8,474	3,259	2,607	0			
	%	100.0	6.4	2.5	6.4	6.4	13.0	17.4	28.3	10.9	8.7	0			
Return	N	135	0	0	0	0	3	18	38	50	18	9	0		
	%	100.0	0	0	0	0	2.2	13.0	28.3	37.0	13.0	6.5	0		
Percent survival		0.450	0	0	0	0	0.08	0.35	0.45	1.53	0.69	--	0		
August ID23, ID26,															
Release	N	82,236	8,470	8,635	6,908	8,566	17,133	8,566	6,853	5,140	6,853	3,427	0	1,713	
	%	100.0	10.3	10.5	8.4	10.4	20.8	10.4	8.3	6.3	8.3	4.2	0	2.1	
Return	N	649	0	0	0	10	30	172	243	112	60	10	10	0	
	%	100.0	0	0	0	1.6	4.7	26.6	37.5	17.2	9.4	1.6	1.6	0	
Percent survival		0.79	0	0	0	0.12	0.18	2.01	3.55	2.18	0.88	0.29	--	0	
September ID27															
Release	N	19,520	1,562	820	0	5,739	2,440	813	813	1,627	1,627	2,440	1,627	0	1,627
	%	100.0	8.0	4.2	0	29.4	12.5	4.2	4.2	8.3	8.3	12.5	8.3	0	8.3
Return	N	228	0	0	0	0	4	22	13	22	45	45	40	22	13
	%	100.0	0	0	0	0	2.0	9.8	4.9	9.8	19.6	19.6	17.6	9.8	5.9
Percent survival		1.17	0	0	0	0	0.16	2.71	1.60	1.35	2.77	1.84	2.46	--	0.80

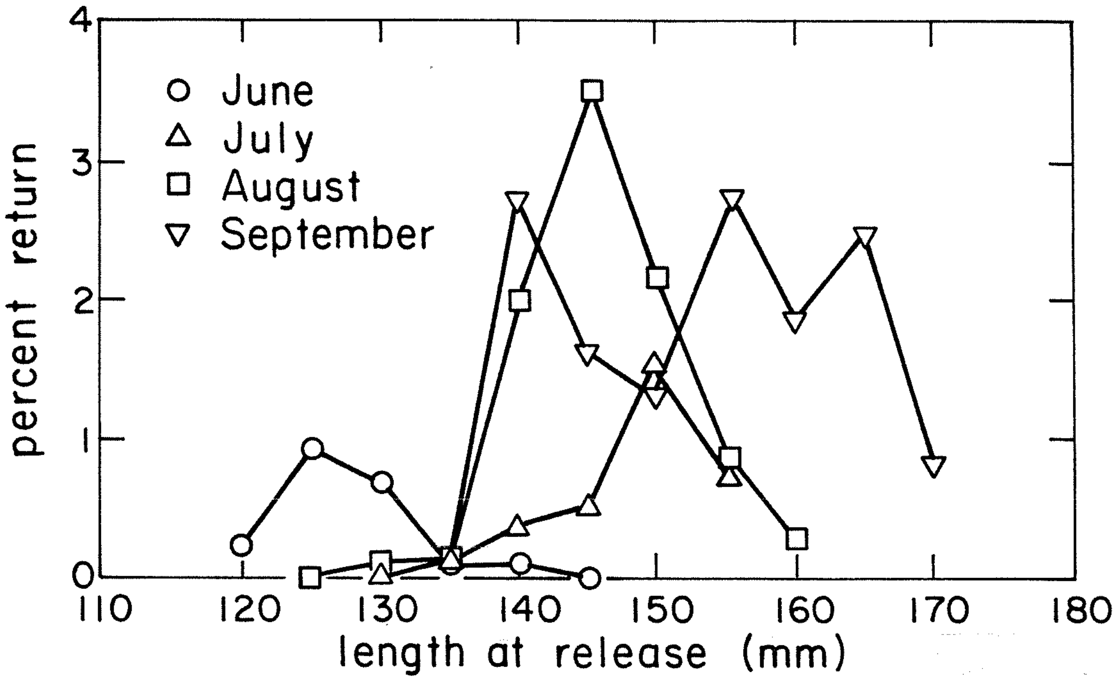

Fig. 4. Optimal size for smolts released in each of the months indicated. The optimality criterion is the percent of all smolts released in each 5 mm length increment that survived to adulthood.

survival of 0.45% with a maximum of 1.50% for 14.5-15.0 cm smolts. Approximately 0.79% of all smolts released in August returned as adults, but specific size classes within these releases exhibited substantially higher survival. Smolts 13.5-14.0 cm showed 2.01% survival, 14.0-14.5 cm smolts showed 3.55% survival, and 14.5-15.0 cm smolts showed 2.18% survival. September release groups returned an average of 1.17% as adults. Although size-specific survival was quite variable, up to 2.77% of some size class releases returned as adults.

The trend in total survival of smolt groups by month of release apparent in Table 5 indicates an important temporal component to the optimal smolt release strategy. The size-class survival curves in Fig. 4 emphasize further that precise combinations of smolt size and release timing greatly influence the probability of survival to adulthood. The biological basis for these patterns of survival is uncertain, but we speculate that they may relate in some way to any or all of the following conditions:

1. Higher smolt quality in later releases. Condition factors increased in smolt groups released later in the summer, indicating that late smolts were heavier per unit of fish length than smolts released earlier. If additional weight served as a physiological buffer against the stress of osmoregulatory adjustment to full strength seawater, then the greater capacity for acclimating to estuarine salinities may account for the higher survival in later smolt releases.

2. Seasonal variation in habitat quality. Habitat quality in this sense encompasses all aspects of the estuarine and nearshore environments that affect smolt survival. Temporal changes in the diversity and abundance of predators, competitors, and prey species encountered by smolts during the seaward migration could regulate the proportion of each smolt release that reaches the open ocean.

3. Differential harvest of smolt groups by the ocean troll fleet. Implicit in this hypothesis are the assumptions that a) returning adults from smolt groups released in different months are segregated in time or space, and b) harvest effort is concentrated in time or space. The differences in survival by month of release shown in Fig. 4 then could be explained as the effect of fishing effort unequally distributed among the release groups composing the adult return.

Given the potential for increasing smolt survival, it seems prudent to investigate in depth the processes that may contribute to the patterns observed in Fig. 4. The hypothetical cases given above indicate several research objectives that could identify the nature of mortality on smolt groups, as well as the specific agents of mortality.

3.4 Ocean Growth of Release Groups

Table 6 shows that differences between groups in the amount of growth added during the first summer at sea follows the expected trend, but these differences are not statistically significant.

Table 6. Growth of juveniles in the ocean expressed as the percentage of ocean scale growth achieved in the first year at sea.

Month of release	Mean distance from focus to margin	Percent of first ocean growth (± 1SD)
May	242.78	65.80 ± 9.25
June	242.08	60.42 ± 6.79
July	233.37	59.83 ± 6.09
August	225.88	59.10 ± 8.14
September	226.59	56.64 ± 7.91

Likewise, correlations between size at release and first ocean growth, size at release and total ocean growth, and first ocean growth and total ocean growth provide little additional information. However, our samples did not contain any of the unusual scales noted during age composition studies of the 1981 return of untagged cohos to OAF-Yaquina Bay (unpublished data).

4.0 CONCLUSIONS AND RECOMMENDATIONS

1. All scale samples should be taken from the preferred area of the fish. We suggest that 3-4 scales in a cluster which includes the preferred scale should be removed from juveniles using fine jeweler's forceps. We have found that smolt scales then may be affixed to gum cards and high-quality acetate replicas made of them. Such a practice will contribute a great deal to the precision of fish size-scale size relationships.

2. Return data from groups investigated in this report suggest that late summer releases of age 0 coho smolts produce the highest return rate, in terms of the percentage of smolts released that return to the hatchery. This result is consistent with that obtained for the 1980 return of age 0 coho. We conclude and recommend that accelerated growth schedules should be designed with the expectation that optimum production will be realized from smolts 14.0 to 15.0 cm (35-43 g) at release in August and September.

3. Maximum returns from June releases may be expected from smolts 12.5 to 13.0 cm in length (22-25 g). Release of fish smaller than 12.0 cm (20 g) or larger than 13.5 cm (28 g) should be avoided. Fish released in July should be 14.5 to 15.5 cm in length (35-42 g).

4. A study should be undertaken to evaluate the effect of the ocean troll fishery on returns of OAF coho adults to the Yaquina Bay release site. Such a study is crucial to identifying the life history stage at which differential survival occurs. The essential question unanswered by the present study is whether or not the difference in percentage return of adults to each group is due to the effects of variable smolt quality between release groups, dynamic ecological relationships during the months of smolt releases, or differential mortality from fishing pressure distributed unevenly among release groups.

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6.0 APPENDIX

Appendix Table 1. Average condition factors for smolt groups released in June - September. Estimates of fish length (mm) were converted to weights (g) by multiplying the average condition factor by the cube of length and dividing the resultant by 100,000.

June	July	August	September
1.140	1.116	1.263	1.224