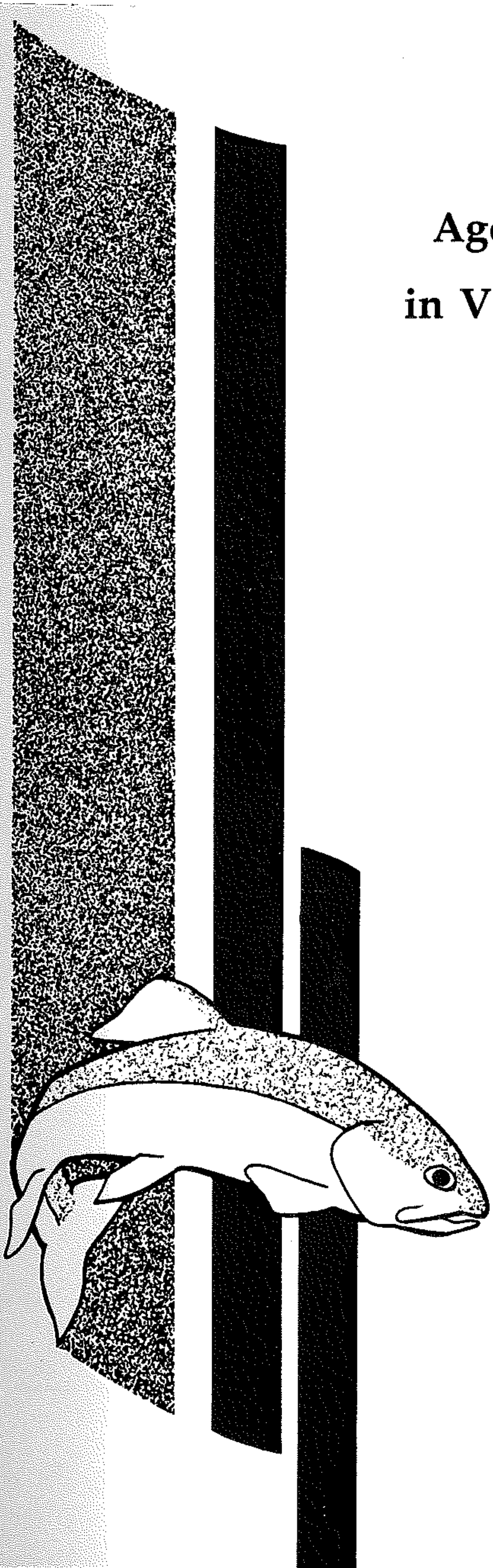

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FISHERIES TECHNICAL CIRCULAR No. 77

1987

Province of British Columbia
Ministry of Environment and Parks

239

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by

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Fisheries Technical Circular No. 77
1987

Canadian Cataloguing in Publication Data

Main entry under title:
Age and growth of steelhead in Vancouver Island
populations

(Fisheries technical circular, ISSN 0229-1150 ; no.
77)

Bibliography: p.
ISBN 0-7726-0707-9

1. Steelhead (Fish) - Age. 2. Steelhead (Fish) -
Growth. I. Hooton, R. S. II. British Columbia.
Ministry of Environment and Parks. III. Series.

QL638.S2A33 1987 597'.55 C87-092174-6

ABSTRACT

R.S. Hooton, B.R. Ward, V.A. Lewynsky, M.G. Lirette and A.R. Facchin. Age and Growth of Steelhead in Vancouver Island Populations. 1987. Fisheries Technical Circular No. 77. 39 p.

This report summarizes life history characteristics of winter and summer runs of wild and hatchery steelhead (since 1952) based on scale analysis. Where possible, annual growth rates and age structures were summarized for each stream and hatchery. To back-calculate lengths from scale measurements, the natural logarithm of scale radii vs the natural logarithm of body length for fish > 45 mm to adult size was used in the Fraser-Lee back-calculation procedure. Separate regression equations were calculated in systems with sufficient data, and for wild and hatchery fish.

Condition factors were highest for wild winter runs, followed by hatchery winter runs, then wild summer runs. Wild winter run fish were mainly 2.2, most wild summer runs were 2.3 and 3.3 at spawning. Winter runs had a higher incidence of repeat spawning. Repeat spawning was higher among females than males.

Mean back-calculated length at smolting for 6 individual river systems ranged from 173 to 185 mm. Mean back-calculated smolt lengths from systems where separate regressions were not available ranged 132 mm (Nimpkish River) to 177 mm (Little Qualicum River).

Back-calculated smolt length increased with freshwater age, and adult length increased with ocean age. Larger smolts tend to have an earlier age-at-return. Back-calculated smolt and ocean age sizes indicated variation in marine growth from 1952 to 1982, mainly evident in the growth from smolting to sea age 1 and from sea age 1 to sea age 2.

Recommendations for aging and back-calculation procedures are included with a discussion of limitations to scale analyses.

ACKNOWLEDGEMENT

This report is the result of numerous man-years of effort by Ministry of Environment and Parks fisheries biologists, technicians and conservation officers over a period exceeding two decades. Direction and coordination of D.R. Hurn and J.C. Lyons during the early years deserves recognition. G.S. Horncastle, L.B. Carswell and F. N. Axford were instrumental in preparation of scale samples for analyses. G.S. Horncastle also coordinated scale interpretation and measurement. A.F. Tautz and P.A. Slaney provided many useful comments during data analyses. L. Evans assisted in the computer analyses. Editing and review of a draft by E.A. Parkinson and A.F. Tautz was appreciated. Drafting was by I. Yesaki.

This report was initially prepared under contract to Supply and Services Canada, DSS Contract No. 035B.FP576-4-0258 by Western Renewable Resources, P.O. Box 2, 100 Mile House, B.C., as subcontractor to W. R. Olmsted & Associates, Inc., North Vancouver, B. C.

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INTRODUCTION

General life history characteristics of most Vancouver Island steelhead trout (Salmo gairdneri) populations are thought to be well known, but age and growth data have only been reported for a small number of populations (Nanaimo River, Narver and Withler 1974; Nahmint River, Narver 1974; Somass River, Horncastle 1981). Life history data for each wild stock help to manage the numerous steelhead fisheries on Vancouver Island. Because forest harvesting, commercial interception, habitat loss and angler use can adversely affect steelhead population structure, the design of appropriate stream-specific habitat protection guidelines and angling regulations requires knowledge of age and growth structure for each population.

This report presents an initial summary of life history characteristics based on scales collected from 16 Vancouver Island drainages since 1952. Where sufficient sample sizes were obtained, annual growth rates and age structure were summarized for each stock.

With increased hatchery production, a major objective was also to describe the life history characteristics of hatchery fish subsequent to their release as smolts.

METHODS

STUDY AREA

Steelhead were collected from drainages (and hatcheries) throughout Vancouver Island (Fig. 1; Table 1). Vancouver Island streams are relatively short and have steep gradients. Discharge is highly responsive to rainfall. Other anadromous salmonid species common to most Vancouver Island streams include: coho (Oncorhynchus kisutch), and chum (O. keta) salmon, cutthroat trout (Salmo clarki) and Dolly Varden char (Salvelinus malma). Sockeye (O. nerka), pink (O. gorbuscha) and chinook salmon (O. tshawytscha) occur in some drainages.

Adult steelhead were sampled opportunistically from angler catch beginning in 1952. A more systematic approach was used to sample both juveniles and adults from 1975 through 1984.

Adult steelhead were sampled from anglers when encountered by MOE staff and during creel surveys, or collected by weirs, seines or gill nets (Table 1). Juveniles were obtained from either weirs, seines, electrofishing or minnow traps, or dip-netted at hatchery ponds. Fork lengths (mm), weight (g), sex (of adults) and scales were obtained for most specimens. Scales were taken from either side of the body three to eight rows above the lateral line between the dorsal and adipose fins, and stored in paper envelopes.

and winter run populations. Sex ratios could not be estimated accurately from anglers' catch since anglers tend to creel females more frequently.

RESULTS AND DISCUSSION

CIRCULI COUNTS ON JUVENILE SCALES

Average circuli counts for smolts were highest between the first and second annuli, but the range of circuli counts did not differ substantially between annuli (Table 2). In both parr and smolts, mean counts and range of counts between annuli decreased with age. Circuli spacing was also variable between annuli of different age groups. Number of circuli to the freshwater margin of smolts from the Big Qualicum and Campbell/Quinsam rivers was highest for the younger smolts (Table 2). Differences in circuli counts, size of the freshwater zone and spacing between circuli might be attributable to environmental or stock differences (Major et al. 1972), but variability in circuli counts between annuli could be the result of missing an annulus in the scale aging process.

BODY LENGTH AND SCALE RADIUS RELATIONSHIPS

The relationship between fork length and scale radius of all life stages combined was curvilinear for both wild (Fig. 2) and hatchery (Fig. 3) steelhead. Logarithmic transformation of scale radius and body length improved the coefficient of determination (r^2) to .98 and .99 from .96 and .98 for wild and hatchery fish, respectively, and stabilized residuals.

Using covariance analysis, several significant differences were found between both slopes and intercepts in the regression of ln(scale radius) and ln(body length). Different slopes existed between wild and hatchery stocks (for both summer and winter run). Different intercepts were found between all wild stocks except the Big Qualicum and Stamp/Somass. A comparison of regression lines of Quinsam hatchery fish to Quinsam wild indicated the same slope but different intercepts. There appears to be justification for using individual intercepts when sample sizes are large. However, many of the differences in slopes and intercepts may have been due to sampling design.

The log-log form was used to back-calculate lengths at age. The transformation in the regression analysis necessitated a corresponding transformation in the Fraser-Lee back-calculation equation, otherwise the assumptions of proportionality would not have been met (Ricker 1968). Fish smaller than 45 mm were excluded from the analysis, since many of the fish sampled below this size were within the period of scale development. Although these small fish would have little influence on the regression with large sample size in the larger size categories, they may have significant leverage where fry sample size is large relative to older fish, even in the log transformed condition. There was no back-calculation to size of 0+ fish, therefore no need to include them in regression.

LENGTH AT AGE

Parr and Smolts

River specific regression equations for both wild and hatchery steelhead were used to back-calculate lengths for the Stamp/Somass (including Robertson Creek), Big Qualicum and Salmon river systems. An equation based on all wild steelhead sampled was used for the other streams (Table 3).

Mean lengths of wild juvenile steelhead at capture were consistently higher than mean back-calculated lengths for each pre-smolt age group in the Stamp/Somass (Table 4), Big Qualicum (Table 5), Gold (Table 6), Salmon (Table 7), Campbell/Quinsam (Table 8) and Cowichan (Table 9) drainages; differences were generally within the limits of seasonal growth.

Mean lengths at each freshwater age back-calculated from wild adult steelhead declined with each older age group among all streams (i.e., Lee's phenomenon: Ricker (1968)). No similar trend was evident among the lengths back-calculated from the juveniles (Tables 4 to 10). The absence of Lee's phenomenon in the juveniles may be related to higher rates of emigration by the larger individuals (smolts) of each age group. For example, since most of the sampling for juveniles occurred during summer and fall, back-calculated length-at-age was based on steelhead that did not smolt that year. These fish may be smaller than those that emigrated, which in turn would also yield smaller back-calculated lengths-at-age. Lee's phenomenon among the adults could be the result of the smaller individuals of each juvenile age group spending more time in freshwater, or, as Ricker (1968) suggests, incorrect back-calculation procedure, non-random sampling (bias to the larger representatives of younger ages), or selective natural mortality of the smaller fish of a given age.

With a few exceptions, mean lengths at freshwater ages 1 to 3 back-calculated from adults were not different between the 14 drainages (Fig. 4; Tables 4 to 10). Age 2 and 3 steelhead in the Campbell/Quinsam rivers (Table 8) and age 3 steelhead from the Cowichan River (Table 9) were larger, whereas back-calculated lengths of age 1 and 2 Nimpkish steelhead (Table 10) were substantially smaller.

In the Big Qualicum and Quinsam rivers, where emigrating smolts were sampled, measured smolt lengths were compared to back-calculated lengths at smolting from returning adults (Tables 5 and 8). Differences may have resulted from year class growth variability, smolt trapping bias, the inability of scale readers to accurately measure the freshwater margin at smolting on adult scales or inaccurate back-calculation of size. However, it appeared, for at least the Quinsam River steelhead, larger smolts experienced higher ocean survival. This was reflected by the back-calculated lengths of age 2+ (182 mm) and 3+ (191 mm) calculated from returning adults, compared to the 2+ (169 mm) and 3+ (177 mm) smolts measured at the fish fence. Big Qualicum measured smolt lengths were not different from back-calculated smolt lengths.

Smolt lengths increased with age in all drainages (Tables 4 to 10). Smolts were consistently larger than parr of the same age and the difference was largest among the younger age groups (Tables 4 to 10). Younger smolts apparently grew faster just prior to smolting than older smolts. This was based on the freshwater margin increment on scales (i.e., "plus growth" during the period between annulus formation and time of ocean entry). By examining freshwater marginal scale increments of emigrating smolts and returning adults, marginal scale growth was considerably higher for younger smolt ages of wild steelhead in both the Big Qualicum and Campbell/Quinsam rivers (Fig. 5).

Back-calculated smolt sizes fell within the range of those reported by Narver and Withler (1971) from Vancouver Island streams (mean = 147 mm), but mean size (about 174 mm, all streams) was higher. Sizes back-calculated from adult scales were more similar to Chilliwack River smolts (Maher and Larkin 1954), Kispiox River smolts (Whately 1977) and Morice River smolts (Whately et al. 1978). Caution must be exercised in these comparisons since the back-calculation procedure differed. Maher and Larkin (1954) used a log-log transformation, as in this study, for the scale measurement and body length regression but they based it on presmolts only. Other studies of back-calculated steelhead smolt length did not perform this log-log transformation nor did they base the regression on all life stages of steelhead (Chapman 1958, Narver 1969, Narver and Withler 1971, Horncastle 1981). However, there remains good evidence for the smolt length 'window' to range from 13 to 25 cm as indicated from Tables 4 - 10 since hatchery smolts released both smaller (Wagner et al. 1963) and larger (Partridge 1985) than this range residualized at high rates.

Adult Steelhead

Measured lengths at age of returning adult winter steelhead were similar to back-calculated lengths in both wild and hatchery fish (cf., Fig. 6 and 7). This implies that despite differences in smolt length upon ocean entry, survivors were ultimately the same size. Relatively higher ocean mortality during the first year has been noted as probably being size-dependent in chum fry (Healey 1982), coho juveniles (Mathews and Buckley 1976), chinook post-smolts (Neilson and Geen 1986) and sockeye post-smolts (Peterman 1982).

No differences were evident among streams in the mean lengths at ocean age in either wild or hatchery winter run steelhead (Table 11). Size at maturity in Atlantic salmon was correlated with river length (Schaffer and Elson 1975) but on Vancouver Island both short (e.g., Amor de Cosmos) and long (e.g., Nanaimo) streams had similar sized adults. Outside this geographic area steelhead appear to vary in size at maturity with latitude (Withler 1966), associated with longer ocean residence in more northern populations.

For summer runs, Tsitika fish were larger at each ocean age than their counterparts from the Ash/Stamp, Gold/Heber and Puntledge rivers (Table 12) but sample sizes were too low to make valid statistical comparisons. There was no difference between mean lengths of wild and hatchery steelhead (all streams and hatcheries combined (Fig. 6; Tables 11 and 12). For the ages that could be compared, winter runs were consistently larger than summer runs (Fig. 7; cf., Tables 11 and 12). Growth of all steelhead was most rapid during the first two years at sea (Fig. 6 and 7).

Adult steelhead exhibited differences in length between the sexes. Regardless of origin (wild or hatchery) or run (winter or summer) males were consistently larger than females (all streams and hatcheries combined) at each ocean age (Fig. 7). This was also consistent among individual streams (Tables 11 and 12). Differences in length were particularly large between the oldest ages. This has been reported previously (Withler 1966) and appears to be common in salmonids (Gardner 1976).

Relationship Between Smolt Size and Adult Size

No obvious relationship was evident between the fork lengths of returning adults and their back-calculated length at smolting (Fig. 8). On closer examination large smolts appeared to return more frequently as sea age 1. Size of smolts appeared to be the same in ocean age 2 and 3 (Fig. 9). Earlier return of larger smolts was common in Atlantic salmon studies (Gardner 1976, Chadwick et al. 1978) and was recorded in Alsea River investigations (Chapman 1958). Hatchery fish provided further evidence for smolt size and/or growth rate influencing age at return (Fig. 9).

OCEAN GROWTH

Variation in marine growth of fish from 1950 to 1981 was tested by anova. Ocean growth was based on differences among the back-calculated lengths at smolting and sea ages 1, 2, and 3. Comparisons of mean growth were done using Scheffe's multiple range test (Sokal and Rohlf, 1969).

Growth of steelhead in their third ocean year did not differ between calendar years (Fig. 10). Growth of wild fish from sea age 1 to 2 was significantly higher during 1968, 1973 and 1974 ($p < 0.05$). Hatchery fish growth during the first and the second ocean year was consistent in that growth within each year-class was simultaneously high or low. Again, a biennial pattern emerged in the data and even years 1976 and 1978 were significantly different from the others ($p < 0.05$, Fig. 10). Growth of hatchery fish from sea age 2 to 3 was similar from 1976 to 1978 but 1979 growth was significantly higher ($p < 0.05$).

Factors affecting these differences in marine growth include sampling bias and sample size, as well as sex, return age and stock. Differences between stocks could not be examined accurately with this data set. The Big Qualicum River fish, having the largest sample size, were used to explore the marine growth characteristics of males vs females (jacks were excluded) and the relationship of marine growth to return age.

Growth from smolting to age 1 was the same in male and female hatchery fish from the Big Qualicum, but the wild males experienced greater growth in length than the wild females ($p < 0.05$). In both wild and hatchery fish, growth in the first year at sea was highest for those that returned at age 2 vs age 3 ($p < 0.05$). This implied that either faster growing steelhead altered age at maturity or else fish that tended to earlier age at maturity inherently grew better.

During the second and third years of ocean residence, males grew longer than females ($p < 0.05$). Fish that matured at age 2 grew less in length during the second year at sea than fish maturing in the next year ($p < 0.05$). Presumably the latter was an effect of preparation for spawning. Males channel less production into maturity than do females; thus the largest members of the adult population are males, as are the smallest (jacks).

An important conclusion from the examination of marine growth was that there was large variability from year to year which was reflected within each age class. In the past, marine conditions were assumed to be stable and non-limiting (Parkinson and Slaney 1975). Although the growth effects to survival and run size cannot be clearly drawn from this study, managers in the future may be better able to predict returns on the basis of marine conditions, given information on smolt production.

MORPHOMETRIC RELATIONSHIPS

Average condition factor was highest for wild winter runs ($k=4.15*10^{-5}$), lowest for wild summer runs ($k=1.33*10^{-5}$), and intermediate for hatchery winter runs ($k=1.85*10^{-5}$) (Table 13). Weight at length was consistently lower in summer steelhead for all lengths, whereas no consistent differences were apparent between wild and hatchery winter runs. Smith (1969) noted that fat content was much higher in summer run fish whereas winter run fish had more highly developed gonads upon river entry.

ADULT STEELHEAD AGE COMPOSITION AND REPEAT SPAWNING FREQUENCIES

Total age (freshwater and ocean age combined) at first spawning differed between wild and hatchery, and winter and summer run steelhead. The most frequent ages at first spawning were age 4 and 5 for wild winter runs, age 3 for hatchery winter runs, ages 4 to 6 for wild summer runs, and ages 3 and 4 for hatchery summer run steelhead (Table 14).

The most frequent age composition for wild winter runs was two freshwater years and two ocean years (i.e., age 2.2); 2.3 and 3.2 were also common. Other ages were rare (Table 15). Most wild summer runs spent two years in freshwater and three at sea (two winters at sea, then migrating the next summer), but a large percentage also reared three years in streams before smolting (Table 15). Thus, a larger percentage of wild summer runs spent one additional year in freshwater and a partial additional year in the marine environment than did winter runs.

Ocean age composition of winter and summer hatchery steelhead was similar to that of the wild fish runs, but most hatchery steelhead smolted at age 1 with little evidence of an additional year of stream residence (Table 16).

The vast majority of steelhead sampled, regardless of origin or run, were returning to spawn for their first time (Table 15 and 16). Winter runs of both wild and hatchery origin had a slightly higher incidence of repeat spawning, with the majority of repeat spawners returning to spawn a second time. The maximum recorded frequency of spawning was four for winter runs, and three for summer runs. The repeat spawning frequencies in Tables 15 and 16 were in close agreement with data presented by Withler (1966) for lower mainland populations.

Repeat spawning frequency was higher among wild steelhead than among hatchery steelhead in both winter and summer runs (Tables 17 and 18). Incidence of repeat spawning was consistently higher in females than males in all streams (Table 17 and 18). Repeat spawning and high variation in age at return has been suggested by Saunders and Schom (1985) to safeguard against loss of stocks, minimize in-breeding and increase the effective population size in Atlantic salmon. On Vancouver Island streams steelhead have adapted to a highly variable freshwater habitat by varying age at smolting. This and varied sea age and multiple spawning insure immigration of at least some spawners in any given season.

LIMITATIONS TO SCALE ANALYSES

Aging of Steelhead

A potential source of error in ageing steelhead by the scale method is the absence of the first annulus. This may occur when temperatures during the growing season are unusually low, spawning occurs late in the season, or steelhead rear in streams where productivity is low. In this study, age 0+ steelhead as large as 46 mm were devoid of scales at the time of sampling. By comparison, size at scale formation is approximately 50 mm in cutthroat trout (Brown and Bailey 1952) and 60 mm in pink salmon (Pearson 1966). Additional evidence of incomplete scale formation at age 1 was the wide range of circuli counts between the scale focus and the first observed annulus (Table 2). For example, it is not known how many circuli must be formed before an age 1 mark can be identified; the formation of only four or five circuli (or more?) at the end of the first growing season would likely be insufficient to form a detectable annulus. Such occurrences would result in unusually high circuli counts between the focus and first annulus, as the first observed annulus would be the age 2 mark.

Because of the uncertainty of the scale method, both annuli and spawning checks should be verified. Scale development and the presence of an age 1 annulus could be assessed for each stream and stock by examining fry sampled between the end of the first growing season and the early spring of the following year (for examination procedure see Averett and MacPhee 1971). Formation of the age 1 annulus could also be examined by comparison with annuli on saggitae otoliths. Absence of the first year annulus in otoliths is highly unlikely as McKern and Horton (1974) found that otoliths appeared in steelhead trout 14 days prior to hatching. Otoliths would also be useful to confirm subsequent annuli and spawning checks. Hatchery steelhead scale interpretations have generally been corroborated through coded wire tagging programs.

Another scale parameter that requires examination is time of annulus formation. Studies to date have implied that annuli for each age all form at the same period, presumably during winter/early spring (Horncastle 1981; Narver 1974; Withler 1966). This assumption may not necessarily be reasonable and should be tested. For example, observed annuli could form at different time periods for steelhead rearing in different ocean regions, and/or adverse conditions that affect growth in streams could result in scale patterns resembling annuli. In addition to mark and recapture and comparisons with otoliths, time of annulus formation could be examined by comparing mean marginal scale (and otolith) increments (distal annulus to edge) for each age class by month. Such a comparison will yield a single pronounced minima when the annual mark is formed.

Back-calculation of lengths

The proportional method is preferred over the regression technique of back-calculation (Whitney and Carlander 1956, Carlander 1981) because variance is less in back-calculated lengths. A most important assumption is that the variables fork length and scale radius are indeed proportional (Ricker 1968).

In this study, the relationship of body length and scale radius was curved with increasing variance. Variance was stabilized and, coincidentally, the regression appeared as a straight line when the variables were transformed.

Errors in back-calculation can develop from a number of areas. The choice of an intercept value might be critical and in this study it appears a standard intercept would not have been acceptable since several significant differences were found between slopes and intercepts. Error was possible from sampling, including scaled site on the fish (Scarnecchia 1979), non-representative samples, differences in year classes and variability in the angle of scale measurement.

Sampling

Although much of the steelhead age and growth characteristics presented in this report may reflect true past histories, caution should be exercised when assessing differences between streams and stocks. Adult steelhead samples in particular may be biased, as they were sampled primarily from angler catch; by nature of the sport, anglers have a tendency to creel and exhibit the largest fish captured. The larger fish tend to be ocean age 3, which may be of different freshwater age than ocean age 2. Ocean age 3 fish are predominantly female and anglers may also tend to creel females to obtain roe.

SUMMARY AND CONCLUSIONS

1. Circuli counts on scales varied between stocks and variation was highest between the first and second annuli possibly as a result of missing an annulus. This could have resulted in errors in aging.

2. Back-calculation of length at age involved transformation (natural logarithm) of scale radii and body length measurements from fish of all ages to obtain an intercept in the relationship of the two variables. The transformation

linearized the relationship and stabilized the variance. The Fraser-Lee method was then used to back-calculate.

3. There was no need to include fish which had not yet developed scales or those that were within the period of scale development.

4. River specific regression equations were used for back-calculation since some intercept differences were significant. It was difficult to determine if differences in backcalculated lengths were real or a result of employing river specific intercepts.

5. Most lengths at freshwater age back-calculated from adults were similar between drainages. However, Nimpkish fish were smaller whereas Campbell/Quinsam and Cowichan fish were larger than the others.

6. Back-calculated smolt length was larger than measured smolt length from Quisam but about the same for the Big Qualicum.

7. Smolt length increased with age and smolts were larger than parr. Younger smolts showed greater "plus" growth than older smolts.

8. Adult length was similar between drainages. Hatchery fish were the same size at age as wild fish. The relationship between smolt size and adult size was poor but smaller adults (sea age 1) appeared to be associated with large smolts.

9. Ocean growth varied most during the first and second years at sea. Biennial patterns were found in both wild (inconsistent) and hatchery fish growth. Ocean conditions for steelhead growth do not appear to be constant.

10. Adult ages were consistent with previous investigations on Vancouver Island (Narver and Withler 1971) and differed in few respects to studies elsewhere (Leider et al. 1985).

11. Summer runs tended to be older in both freshwater and saltwater years. Wild and hatchery fish were of the same ocean age.

12. Repeat spawning frequency was higher among wild fish, greater in winter runs than summer, and higher in females.

13. Conclusions drawn from this data remain speculative since the sampling was often by convenience and biased.

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Table 1. Year, collection method and numbers of juvenile and adult steelhead trout sampled from Vancouver Island streams and hatcheries[a].

Stream	Origin	Stock	Fry/Parr			Smolts			Adults		
			Years	Method	N	Years	Method	N	Years[b]	Method	N
1. Amor de Cosmos	W[c]	w[e]							75-76	Ag	15
2. Big Qualicum	W	w	79-80	Mt,Ef	298	66,80-81	Wr	212	Int 52-82	Ag,Wr	1433
	H[d]	w	79-80	Dn,Sg	250	78-81	Dn,Wr	217	Int 52-32	Ag,Wr	945
3. Campbell/Quinsam	W	w	76-81	Wr,Ef,Mt	760	76-81	Wr	548	75-82	Ag,Wr	450
	H	w	79-80	Dn	249	78-80	Dn	51	77-82	Ag,Wr,Gn	161
4. Cowichan	W	w	83	Ef,Mt	318				59-65,80-82	Ag	364
5. De Mamiel	W	w							61-64	Ag	6
6. Englishman	W	w							Int 52-82	Ag,Sg	138
7. Gold/Heber	W	w	76,78	Mt	311				61,74-77,82	Ag	158
	W	s[f]							74-77,81	Sg,Ag	218
8. Little Qualicum	W	w							52-53,75-78	Ag	25
9. Nanaimo	W	w							Int 53-82	Ag	162
10. Nimpkish	W	w							52,75-76	Ag	20
11. Oyster	W	w							Int 53-82	Ag	109
12. Puntledge	W	w							53,81-82	Ag	107
13. Salmon/Memekay	W	w	80-81	Mt,Ef	322				58,76-82	Ag	165
	H	w	80-81	Dn,Ef,Mt	357				81-82	Ag	8
14. Sooke	W	w							58-63	Ag	39
15. Somass	W	w	78	Mt	22				77-78	Ag	74
16. Stamp/Ash	W	w	76-80	Ef,Mt	462				76-82	Wr,Ag	93
	W	s							76,78	Wr,Ag	54
	H	s							77-78	Wr	42
17. Robertson	W	w							79-82	Wr	51
	W	s							77-82	Wr,Ag	230
	H	w							79-80	Wr	33
	H	s	79-80,83	Dn	300				80-84	Wr,Ag	1215
18. Tsitika	W	s	78	Ef	93				79-82	Ag	58

[a] Capture method codes: Ag-angling; Dn-dip net; Ef-electrofishing; Gn-gillnet; Mt-minnow trap; Sg-seining; Wr-weir.

[b] Int-intermittent. [c] W-wild. [d] H-hatchery. [e] w-winter. [f] s-summer

Table 2. Number of circuli between freshwater annuli and in the distal freshwater margin during year of smolting on scales of wild steelhead smolts collected from the Big Qualicum and Quinsam Rivers.

Age at Smolting	N	Focus-Annulus 1		Annulus 1-2		Annulus 2-3		Annulus 3-4		Last annulus -Freshwater Margin	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
					BIG QUALICUM						
1.0	3	15.1	12-17							10.7	10-11
2.0	23	10.3	6-18	10.9	7-17					4.8	0-9
3.0	4	8.3	7-11	10.3	8-13	8.7	8-10			5.8	5-6
4.0	0										
All Ages		10.5	6-18	10.8	7-17	8.7	8-10			5.5	0-11
					QUINSAM						
1.0	0										
2.0	170	12.4	7-19	14.1	6-21					2.7	0-8
3.0	110	11.1	6-18	12.3	8-18	9.6	6-17			0.6	0-5
4.0	9	8.4	6-15	10.9	7-15	10.7	8-14	9.6	6-13	0.4	0-4
All Ages		11.7	6-19	13.3	6-21	9.7	6-17	9.6	6-13	1.8	0-8

Table 3. Length-scale regression equations used to back-calculate lengths at freshwater ages and at smolting for wild and hatchery steelhead trout. Regression equations are based on logarithms of fork lengths and scale radii of steelhead trout age 0+ and older collected from Vancouver Island streams and hatcheries, 1966-81.

System	Stock	Sample Size			Length-scale regression equation[a]	r^2
		Juveniles	Smolts	Adults		
			WILD			
Big Qualicum	winter	238	151	740	$\ln(L) = .865\ (\ln(s)) + 1.407$	.98
Campbell/Quinsam	winter	557	366	273	$\ln(L) = .869\ (\ln(s)) + 1.323$	.98
Salmon	winter	305	2	27	$\ln(L) = .863\ (\ln(s)) + 1.323$	.97
Stamp/Somass[c]	summer/winter[b]	375	0	131	$\ln(L) = .831\ (\ln(s)) + 1.534$	.98
Cowichan	winter	312	0	22	$\ln(L) = .873\ (\ln(s)) + 1.245$	.97
All streams		2165	519	1487	$\ln(L) = .876\ (\ln(s)) + 1.308$	.98
			HATCHERY			
Big Qualicum	winter	225	138	603	$\ln(L) = .851\ (\ln(s)) + 1.389$	.99
Quinsam	winter	201	9	75	$\ln(L) = .862\ (\ln(s)) + 1.326$	.99
Robertson	summer	211	24	28	$\ln(L) = .844\ (\ln(s)) + 1.413$	.97
All hatcheries		1016	171	707	$\ln(L) = .859\ (\ln(s)) + 1.338$	.99

[a] Based on lengths greater than 45 mm (i.e., fish possessing scales): L = estimated fork lengths (mm), s = scale radius magnified 100 x's, ln = natural logarithm.

[b] summer and winter juveniles and winter adults only

[c] includes Ash River.

Table 4. Measured and back-calculated fork lengths (mm) of wild juvenile (summer and winter runs) and adult steelhead trout winter runs during freshwater residency in the Ash, Stamp and Somass rivers.

Age Group	Length at Capture Parr N	 Mean	 SD	 Smolts N	 Mean	 SD	Mean Calculated Length At End of Year 1	 2	 3	 4	 At Smolting
					JUVENILES						
0+ .0	213	49	13.8								
1+ .0	260	102	26.1				64				
2+ .0	15	140	28.4				60	114			
3+ .0	1	225					86	102	178		
Weighted mean							64	114	178		
Growth increment							64	50	64		
					ADULTS						
1. *							138				171
2. *							86	172			180
3. *							73	138	185		186
4. *							82	168	198	234	234
Weighted mean							84	163	185	234	182
Growth increment							84	79	22	49	

* Ocean years pooled

Table 5. Measured and back-calculated fork lengths (mm) of wild juvenile and adult steelhead trout (winter run) during freshwater residency in the Big Qualicum River.

Age Group	Length at Capture All Fish N	 Mean	 SD	 Smolts N	 Mean	 SD	Mean Calculated Length At End of Year 1	 2	 3	 4	 At Smolting
					JUVENILES						
0+ .0	207	66	20.1								
1+ .0	108	130	26.7	32	159	17.7	89				
2+ .0	107	180	24.0	105	181	23.3	87	141			
3+ .0	15	209	29.9	15	209	29.9	85	140	180		
Weighted mean					179	26.5	88	141	180		
Growth increment							88	53	39		
					ADULTS						
1. *	114						109				162
2. *	532						84	147			176
3. *	91						79	139	187		198
4. *	2						68	99	143	170	170
Weighted mean							88	146	186	170	177
Growth increment							88	58	40	(-16)	

* Ocean years pooled

Table 6. Measured and back-calculated fork lengths (mm) of wild juvenile (summer and winter runs) and adult steelhead trout winter runs during freshwater residency in the Gold and Heber rivers.

Age Group	Lengths at Capture: Parr N	Parr Mean	Parr SD	Smolts N	Smolts Mean	Smolts SD	Mean Calculated Length: At End of Year 1	2	3	4	At Smolting
					JUVENILES						
1+ .0	111	93	20.7				54				
2+ .0	148	112	16.4				54	94			
3+ .0	39	127	25.1				48	88	117		
4+ .0	1	139					39	86	111	133	
Weighted mean							53	92	116	133	
Growth increment							53	39	24	17	
					ADULTS						
1. *	1						152				152
2. *	45						91	165			165
3. *	42						81	137	186		186
4. *	1						56	90	132	162	162
Weighted mean							87	151	185	162	175
Growth increment							87	64	34	(-23)	

* Ocean years pooled

Table 7. Measured and back-calculated fork lengths (mm) of wild juvenile and adult steelhead trout (winter run) during freshwater residency in the Salmon River[a].

Age Group	Lengths at Capture: Parr N	Parr Mean	Parr SD	Smolts N	Smolts Mean	Smolts SD	Mean Calculated Length: At End of Year 1	2	3	4	At Smolting
					JUVENILES						
0.0	90	63	11.0								
1+ .0	126	86	21.1				67				
2+ .0	84	118	19.6				66	105			
3+ .0	10	157	30.8	2	165	11.3	77	115	149		
Weighted mean							69	106	149		
Growth increment							69	37	43		
					ADULTS						
1. *											
2. *	18						91	149			172
3. *	9						78	127	166		175
4. *											
Weighted mean							86	142	166		173
Growth increment							86	56	24		

[a] Includes Memekay River

* Ocean years pooled

Table 8. Measured and back-calculated fork lengths (mm) of wild juvenile and adult steelhead trout (winter run) during freshwater residency in the Campbell/Quinsam River.

Age Group	Length at Capture						Mean Calculated Length				
	All Fish			Smolts			At End of Year				At Smolting
	N	Mean	SD	N	Mean	SD	1	2	3	4	
					JUVENILES						
0+.0	244	55.6	15.6								
1+.0	372	101.7	18.4	7	154.0	12.4	68				
2+.0	268	164.8	20.3	241	168.8	16.8	72	135			
3+.0	113	177.1	23.3	113	177.1	23.3	71	126	169		
4+.0	9	200.3	27.9	9	200.3	27.9	61	107	155	196	
Weighted Mean					172	20.2	70	132	168	196	
Growth Increment							70	62	36	28	
					ADULTS						
1. *	1						136				136
2. *	179						77	157			182
3. *	89						67	127	178		191
4. *	3						50	92	141	151	186
Weighted Mean							74	147	177	151	185
Growth Increment							74	73	30	(-26)	

* Ocean years pooled

Table 9. Measured and back-calculated fork lengths (mm) of wild juvenile and adult steelhead trout during freshwater residency in the Cowichan River.

Age Group	Length at Capture						Mean Calculated Length				
	All Fish			Smolts			At End of Year				At Smolting
	N	Mean	SD	N	Mean	SD	1	2	3	4	
					JUVENILES						
0+.0	206	73	17.4								
1+.0	110	127	17.8				66				
2+.0	2	161	28.2				76	135			
Weighted Mean							66	135			
Growth Increment							66	69			
					ADULTS						
1. *	12						101				171
2. *	7						84	151			181
3. *	3						68	152	226		240
Weighted Mean							91	151	226		183
Growth Increment							91	60	75		

* Ocean years pooled

Table 10. Back-calculated fork lengths (mm) of wild winter (1952-82) run adult steelhead trout during freshwater residency and at smolting in 8 Vancouver Island streams.

			Mean Calculated Length				
			At End of Year				At
Stream	Age[a] Group	N	1.0	2.0	3.0	4.0	Smolting
Amor de Cosmos	1. *						
	2. *	5	85	156			156
	3. *	4	76	133	178		178
	Weighted Mean		81	146	178		166
	Growth Increment		81	65	32		
Englishman	1. *						
	2. *	24	89	146			165
	3. *	8	83	139	181		188
	Weighted Mean		88	144	181		170
	Growth Increment		88	56	37		
Little Qualicum	1. *						
	2. *	9	86	161			177
	3. *	1	72	124	170		170
	Weighted Mean		85	158	170		177
	Growth Increment		85	73	12		
Nanaimo	1. *						
	2. *	45	87	149			162
	3. *	5	72	127	168		174
	Weighted Mean		86	147	168		163
	Growth Increment		86	61	21		
Nimpkish	1. *						
	2. *	9	64	109			118
	3. *	4	58	100	156		163
	Weighted Mean		62	107	156		132
	Growth Increment		62				
Oyster	1. *	1	106				167
	2. *	28	89	148			163
	3. *	4	79	134	187		187
	Weighted Mean		89	147	187		165
	Growth Increment		89	45	40		
Sooke	1. *						
	2. *	19	87	155			155
	3. *	10	94	149	200		200
	4. *	1	76	120	158	201	201
	Weighted Mean		89	151	196	201	171
	Growth Increment		89	62	45	5	
Puntledge	1. *	1	132				181
	2. *	22	91	161			172
	3. *	5	78	130	167		167
	Weighted Mean		90	156	167		171
	Growth Increment		90	66	11		

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[a] Ocean years pooled

Table 11. Measured fork lengths (mm) of adult wild and hatchery winter run steelhead (by sex and ocean age) captured from Vancouver Island streams, 1952 to 1982.

	Male												Female											
	Age .1			Age .2			Age .3			Age .4			Age .1			Age .2			Age .3			Age .4		
Stream	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N
												WILD												
Amor de Cosmos			0	701	680-737	3	909	864-953	2	889		1			0	686		1	784	686-857	7	825		1
Big Qualicum	474	410-665	17	670	465-850	381	796	340-960	95	836	720-1030	4	514	422-615	7	653	410-820	459	757	610-860	260	802	730-916	44
Campbell/Quinsam			0	699	595-927	52	881	737-1040	72	944	851-1016	6			0	675	560-813	97	801	692-973	137	840	745-941	9
Cowichan	525	500-559	3	666	559-832	161	758	660-889	104	801	660-914	19	526	460-635	11	682	506-819	86	803	594-965	25	815	795-851	3
Englishman			0	697	570-790	12	839	690-950	10			0			0	669	610-790	23	782	670-890	30	860		1
Gold			0	682	270-756	20	870	667-977	29	803	787-819	2			0	662	610-711	18	803	635-922	38	829	743-889	5
Little Qualicum	483		1	671	660-685	3	864		1	902		1			0	658	597-724	10	772	711-838	5	787		1
Nanaimo			0	664	565-736	38	817	700-910	25	876		1			0	665	600-790	40	767	558-880	52	781	762-800	2
Nimpkish			0			0	877	864-902	6			0			0	641		1	818	787-864	8	784		1
Oyster			0	685	630-750	15	855	760-970	5			0			0	661	590-725	22	794	710-902	25	795	718-845	4
Puntledge			0	674	575-745	25	796	660-845	8			0			0	645	482-715	34	786	660-915	30	865	819-910	2
Salmon	457	406-508	2	675	612-737	14	889	760-972	10	876		1			0	627	565-710	14	812	711-914	24	850	790-922	3
Sooke			0	693	609-775	13			0			0			0	640	559-736	21	806		1	743		1
Stamp/Somass	470		1	705	536-826	35	821	711-965	19	965		1			0	666	586-813	66	747	557-889	43	803	724-889	9
All streams	473	406-665	21	676	270-927	614	837	340-1040	384	889	720-1030	17	514	422-615	7	657	410-820	820	776	557-973	695	810	718-941	86
												HATCHERY												
Big Qualicum	493	420-620	3	688	506-800	221	820	650-940	57			0	443	385-500	2	674	95-775	286	787	650-885	213	802	750-850	9
Quinsam			0	657	580-720	11	834	762-946	16	914		1			0	661	584-740	10	781	610-864	71	805	737-890	3
All hatcheries	493	420-620	3	685	506-800	233	828	650-946	68	914		1	410	345-500	3	668	95-775	310	778	565-885	300	803	737-890	12

Table 12. Measured fork lengths (mm) of adult wild and hatchery summer run steelhead (by sex and ocean age) captured from Vancouver Island streams, 1952 to 1982.

	Male												Female											
	Age .1			Age .2			Age .3			Age .4			Age .1			Age .2			Age .3			Age .4		
Stream	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N
												WILD												
Ash/Stamp			0	558	461-660	54	707	592-953	63			0	351		1	559	474-677	40	652	564-800	107	633	582-671	4
Gold/Heber			0	529	457-572	13	701	572-813	15			0			0	544	489-597	11	660	260-794	58	737	699-775	2
Puntledge			0	552	485-756	11	705	665-882	11			0			0	570	489-565	3	688	622-788	18	672		1
Tsitika			0	590		1	757	660-813	11			0			0			0	723	635-800	22			0
All streams			0	553	461-660	79	711	572-953	100			0	351		1	557	474-677	54	666	260-800	202	668	582-775	7
												HATCHERY												
Robertson			0	593	430-600	517	706	525-900	323	726	662-818	6	453		1	565	478-714	234	663	523-823	404			

Table 13. Length(mm)-weight(g) regression equations for juvenile and adult steelhead captured in Vancouver Island streams[a].

Stock	N	Logarithm Regression Equation	Goodness of Fit(r^2)	Anti-log Length-weight Relationship
		JUVENILE		
Wild Winter Run	629	$\ln(W) = 2.746*\ln(L) - 10.311$	0.99	$W = 0.0000333*L^{2.746}$
		ADULT		
Wild Winter Run	1297	$\ln(W) = 2.785*\ln(L) - 10.090$	0.88	$W = 0.0000415*L^{2.785}$
Wild Summer Run	40	$\ln(W) = 2.946*\ln(L) - 11.224$	0.93	$W = 0.0000133*L^{2.946}$
Hatchery Winter Run	258	$\ln(W) = 2.903*\ln(W) - 10.898$	0.88	$W = 0.0000185*L^{2.903}$

[a] Juvenile steelhead were obtained from the Big Qualicum and Quinsam Rivers; see Table 1 for stream composition of adult steelhead.

Table 14. Relative frequencies (%) of total age at first spawning by summer and winter run steelhead collected from Vancouver Island streams and hatcheries between 1952 and 1982.

		Total age at spawning						
Stream	N	2	3	4	5	6	7	8
		WILD WINTER RUN						
Amor de Cosmos	9				88.9	11.1		
Big Qualicum	846	0.1	13.0	59.9	25.8	1.2		
Campbell/Quinsam	350		0.3	27.7	56.6	14.6	0.9	
Cowichan	489	0.8	35.6	49.9	12.7	1.0		
Englishman	112		0.9	45.5	49.1	4.5		
Gold	119		0.8	24.4	40.3	32.8	0.8	0.8
Little Qualicum	41	2.4	0	63.4	29.3	4.9		
Nanaimo	122			43.4	52.5	4.1		
Nimpkish	18			5.6	66.7	27.8		
Oyster	67		1.5	58.2	40.3			
Puntledge	75		2.7	62.7	34.7			
Salmon	118		0.8	28.0	55.9	14.4	0.8	
Sooke	31			61.3	35.5	3.2		
Stamp/Somass	180		2.8	43.9	46.7	6.7		
All streams	2161	0.1	5.9	47.1	39.5	7.0	0.2	0.1
		WILD SUMMER RUN						
Ash/Stamp	227		4.4	54.2	37.0	4.0		0.4
Gold/Heber	150			4.0	40.0	52.0	4.0	
Puntledge	42		14.3	26.2	50.0	9.5		
Tsitika	37				18.9	75.7	5.4	
All streams	456		3.5	30.6	38.0	26.0	1.7	0.2
		HATCHERY WINTER RUN						
Big Qualicum	757	0.9	68.6	30.5				
Quinsam	133	1.5	23.3	75.2				
Robertson	29	3.4	37.9	55.2	3.4			
All hatcheries	919	1.1	60.9	37.8	0.3			
		HATCHERY SUMMER RUN						
Robertson	1570		48.0	51.5	0.5			

Table 15. Ocean age at spawning and repeat spawning frequencies cross-classified by smolting age by winter and summer run wild steelhead collected from Vancouver Island streams.

Age at Smolting	Ocean Age at First Spawning						Spawning Incidence					
	.1	.2	.3	.4	All	Percent	1st	2nd	3rd	4th	Total	Percent
						WINTER RUN						
1.	2	136	78	0	216	8.8	191	21	4	0	216	8.8
2.	18	1107	566	6	1697	68.8	1491	168	31	7	1697	68.8
3.	12	376	149	2	539	21.9	478	50	10	1	539	21.9
4.	0	10	4	0	14	0.6	13	1	0	0	14	0.6
All Ages	32	1629	797	8	2466		2173	240	45	8	2466	
Percent	1.3	66.1	32.3	0.3		100.0	88.1	9.7	1.8	0.3		100.0
						SUMMER RUN						
1.	0	20	67	0	87	17.5	82	4	1	0	87	17.5
2.	2	80	156	2	240	48.3	232	8	0	0	240	48.3
3.	4	23	132	0	159	32.0	137	19	3	0	159	32.0
4.	0	6	5	0	11	2.2	11	0	0	0	11	2.2
All Ages	6	129	360	2	497		462	31	4	0	497	
Percent	1.2	26.0	72.4	0.4		100.0	93.0	6.2	0.8	0.0		100.0

Table 16. Ocean age at spawning and repeat spawning frequencies cross-classified by smolting age by winter and summer run hatchery steelhead collected from Vancouver Island streams.

Age at Smolting	Ocean Age at First Spawning						Spawning Incidence					
	.1	.2	.3	.4	All	Percent	1st	2nd	3rd	4th	Total	Percent
WINTER RUN												
1.	20	643	350	0	1013	98.3	929	74	8	2	1013	98.3
2.	1	12	4	0	17	1.7	13	3	1	0	17	1.7
All Ages	21	655	354	0	1030		942	77	9	2	1030	
Percent	2.0	63.6	34.4	0.0		100.0	91.5	7.5	0.9	0.2		100.0
SUMMER RUN												
1.	0	197	332	6	535	98.7	530	5	0	0	535	98.7
2.	1	2	4	0	7	1.3	7	0	0	0	7	1.3
All Ages	1	199	336	6	542		537	5	0	0	542	
Percent	0.2	36.7	62.0	1.1		100.0	99.1	0.9	0.0	0.0		100.0

Table 17. Repeat spawning frequencies of wild and hatchery winter run steelhead (by sex) collected from Vancouver Island streams, 1952 to 1982.

System	Number of Fish Captured	Repeat Spawners					Relative Frequency of Spawning (%)							
		Males		Females		Ratio (F:M)	Male				Female			
		N	%	N	%		1st	2nd	3rd	4th	1st	2nd	3rd	4th
						WILD WINTER RUN								
Amor de Cosmos	15	1	6.7	1	6.7	1:1	83.3	0.0	16.7	0.0	88.9	11.1	0.0	0.0
Big Qualicum	1272	32	2.5	145	11.4	4.5:1	93.6	5.6	0.4	0.4	81.2	15.3	3.2	0.3
Campbell/Quinsam	375	10	2.7	25	6.7	2.5:1	92.4	5.3	2.3	0.0	89.8	9.8	0.0	0.4
Cowichan	529	8	1.5	63	11.9	2:1	100.0	0.0	0.0	0.0	82.5	15.9	1.6	0.0
Englishman	77	2	2.6	11	14.3	5.5:1	90.9	9.1	0.0	0.0	80.0	18.2	1.8	0.0
Gold	112	7	6.3	11	9.8	1.6:1	86.0	10.0	4.0	0.0	82.3	11.3	6.5	0.0
Little Qualicum	24	1	4.2	4	16.7	4:1	83.3	16.7	0.0	0.0	77.8	11.1	5.6	5.6
Nanaimo	161	5	3.1	15	9.3	3:1	92.3	7.7	0.0	0.0	84.4	11.5	4.2	0.0
Nimpkish	16	0	0.0	1	6.3	1:0	100.0	0.0	0.0	0.0	90.0	10.0	0.0	0.0
Oyster	71	0	0.0	10	14.1	10:0	100.0	0.0	0.0	0.0	80.4	11.8	7.8	0.0
Puntledge	100	1	1.0	12	12.0	12:1	97.0	3.0	0.0	0.0	82.1	14.9	1.5	1.5
Salmon	69	1	1.4	8	11.6	8:1	96.3	3.7	0.0	0.0	81.0	14.3	4.8	0.0
Sooke	40	0	0.0	5	12.5	5.5:1	100.0	0.0	0.0	0.0	81.5	14.8	3.7	0.0
Stamp/Somass	176	1	0.6	16	9.1	16:1	98.2	1.8	0.0	0.0	86.7	10.0	2.5	0.8
All streams	2585	64	2.5	270	10.4	4.2:1	93.3	5.6	0.8	0.2	83.4	13.4	2.8	0.4
						HATCHERY WINTER RUN								
Big Qualicum	791	10	1.3	60	7.6	6:1	96.4	3.6	0.0	0.0	88.2	10.2	1.2	0.4
Quinsam	112	1	0.9	7	6.3	7:1	96.4	3.6	0.0	0.0	91.7	6.0	2.4	0.0
Robertson	34	0	0.0	0	0.0		100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
All hatcheries	937	11	1.2	67	7.2	6.1:1	96.5	3.5	0.0	0.0	89.3	9.1	1.3	0.3

Table 18. Repeat spawning frequencies of wild and hatchery summer run steelhead (by sex) collected from Vancouver Island streams, 1952 to 1982.

		Repeat Spawners					Relative Frequency of Spawning (%)							
		Males		Females			Male				Female			
System	Number of Fish Captured	N	%	N	%	Ratio (F:M)	1st	2nd	3rd	4th	1st	2nd	3rd	4th
						WILD SUMMER RUN								
Ash/Stamp	274	3	1.1	7	2.6	2.3:1	97.5	2.5	0.0	0.0	95.5	3.9	0.6	0.0
Gold/Heber	105	3	2.9	8	7.6	2.7:1	90.3	9.7	0.0	0.0	89.2	10.8	0.0	0.0
Puntledge	44	0	0.0	2	4.5	2:0	100.0	0.0	0.0	0.0	90.9	9.1	0.0	0.0
Tsitika	45	2	4.4	9	20.0	4.5:1	85.7	14.3	0.0	0.0	71.0	22.6	6.5	0.0
All streams	468	8	1.7	26	5.6	3.3:1	95.7	4.3	0.0	0.0	90.7	8.2	1.1	0.0
						HATCHERY SUMMER RUN								
Robertson[a] [b]	1670	2	0.1	3	0.1	1.5:1	100.0				100.0			

[a] Includes scale sampled and coded wire tagged fish.

[b] Potential repeat spawning frequency minimized due to removal of these fish at the hatchery rack.

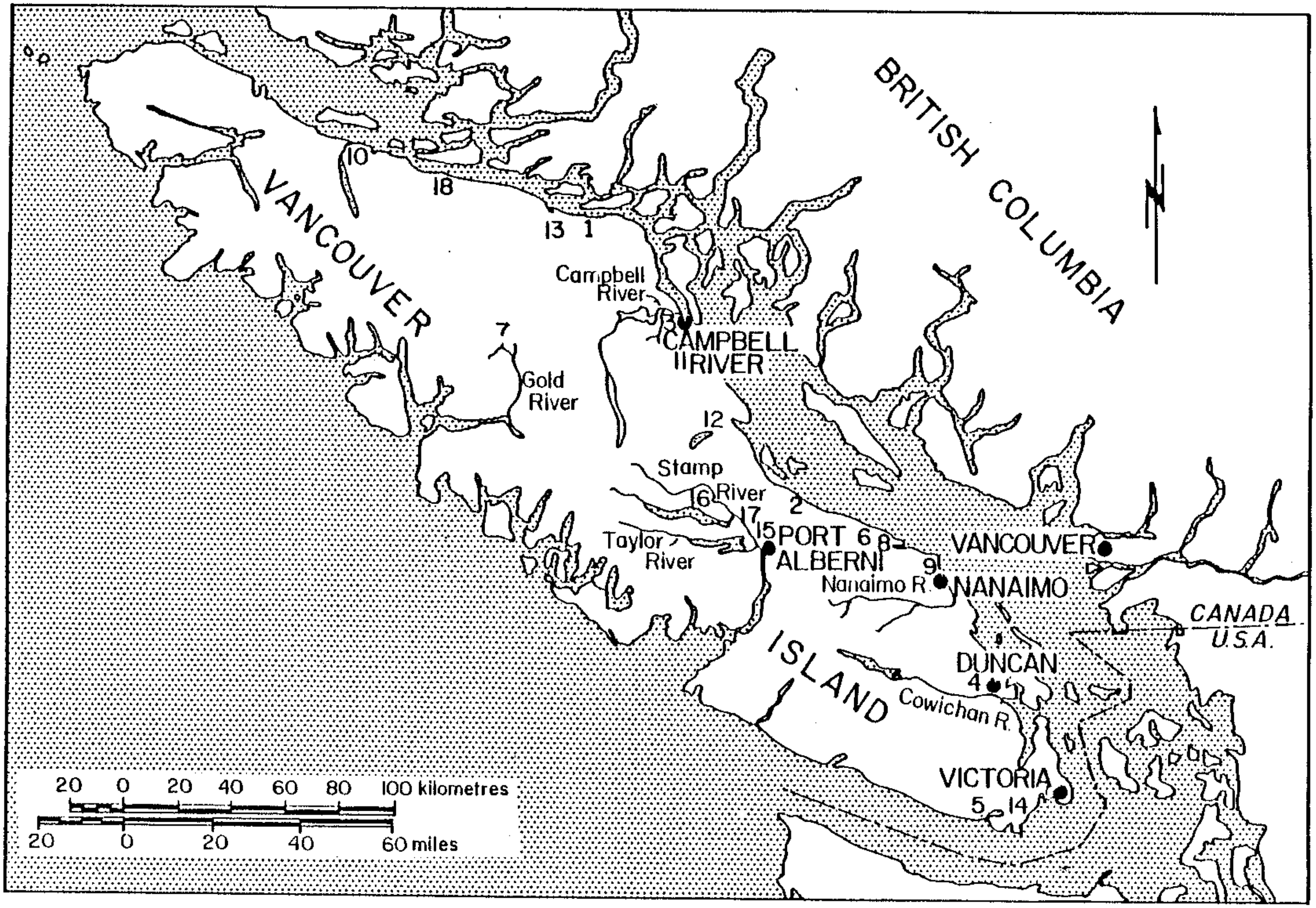

Fig. 1. Vancouver Island showing locations of streams mentioned in the text. Numbers refer to list in Table 1.

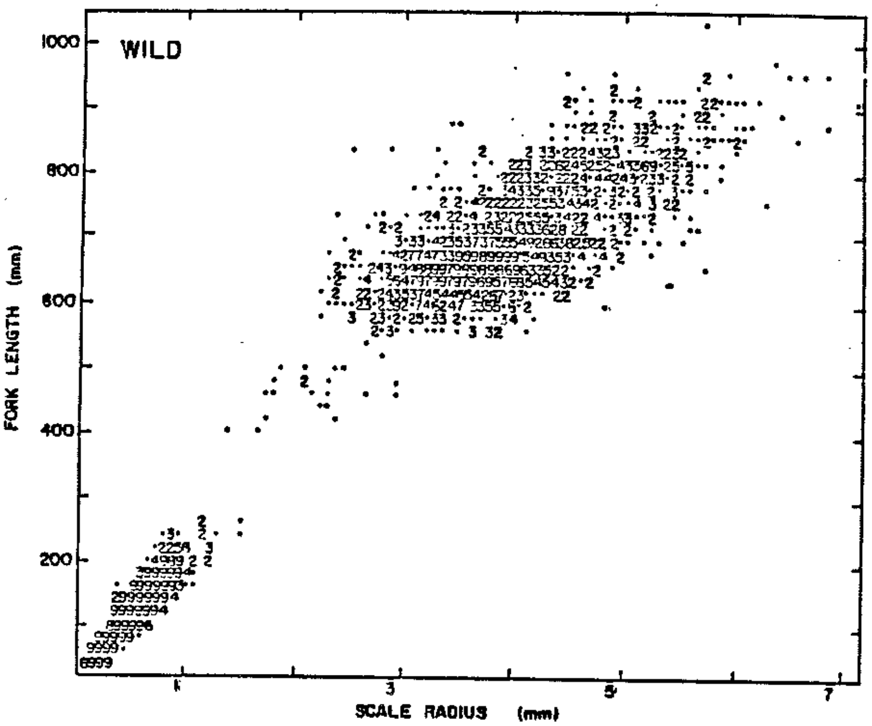

Fig. 2. Relationship between fork length and scale radius for wild steelhead trout from Vancouver Island streams. Numbers indicate frequencies greater than one.

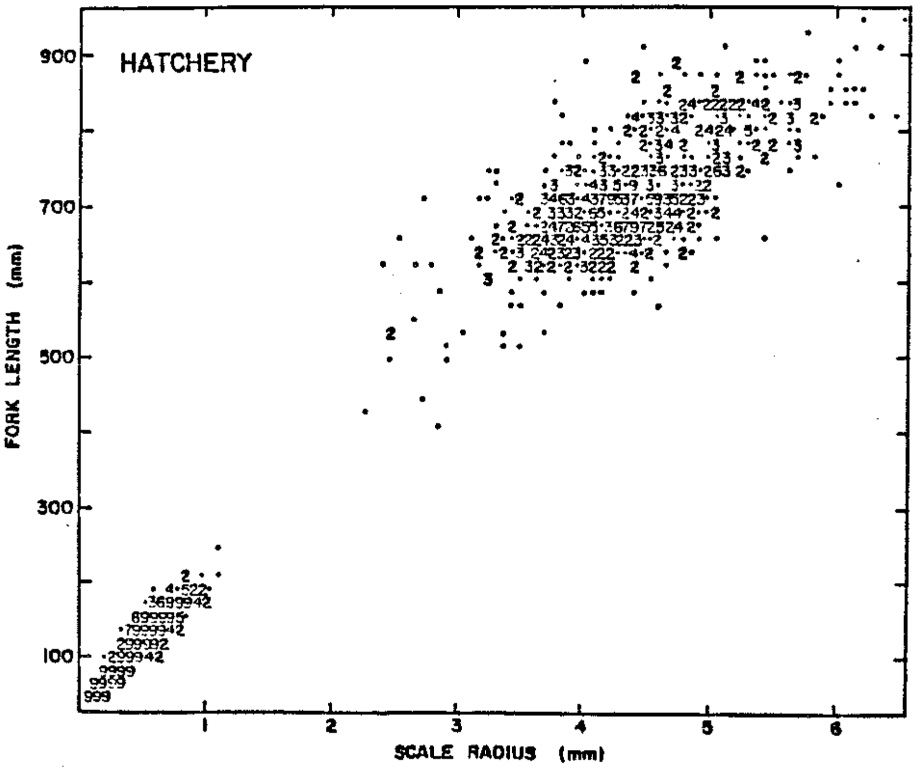

Fig. 3. Relationship between fork length and scale radius for hatchery steelhead trout from Vancouver Island streams.

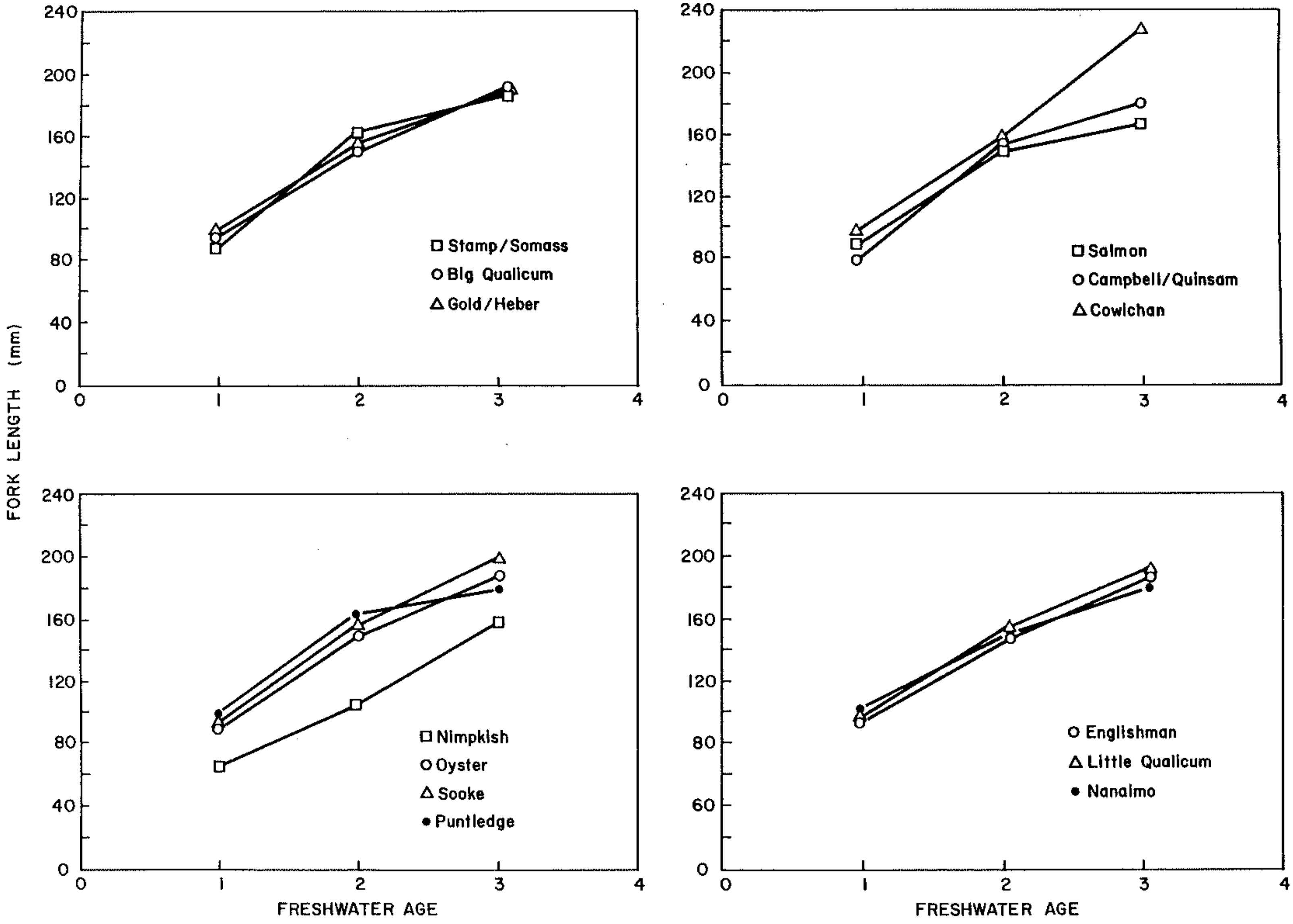

Fig. 4. Mean fork lengths at freshwater age back-calculated from wild adult steelhead returning to 13 Vancouver Island drainages.

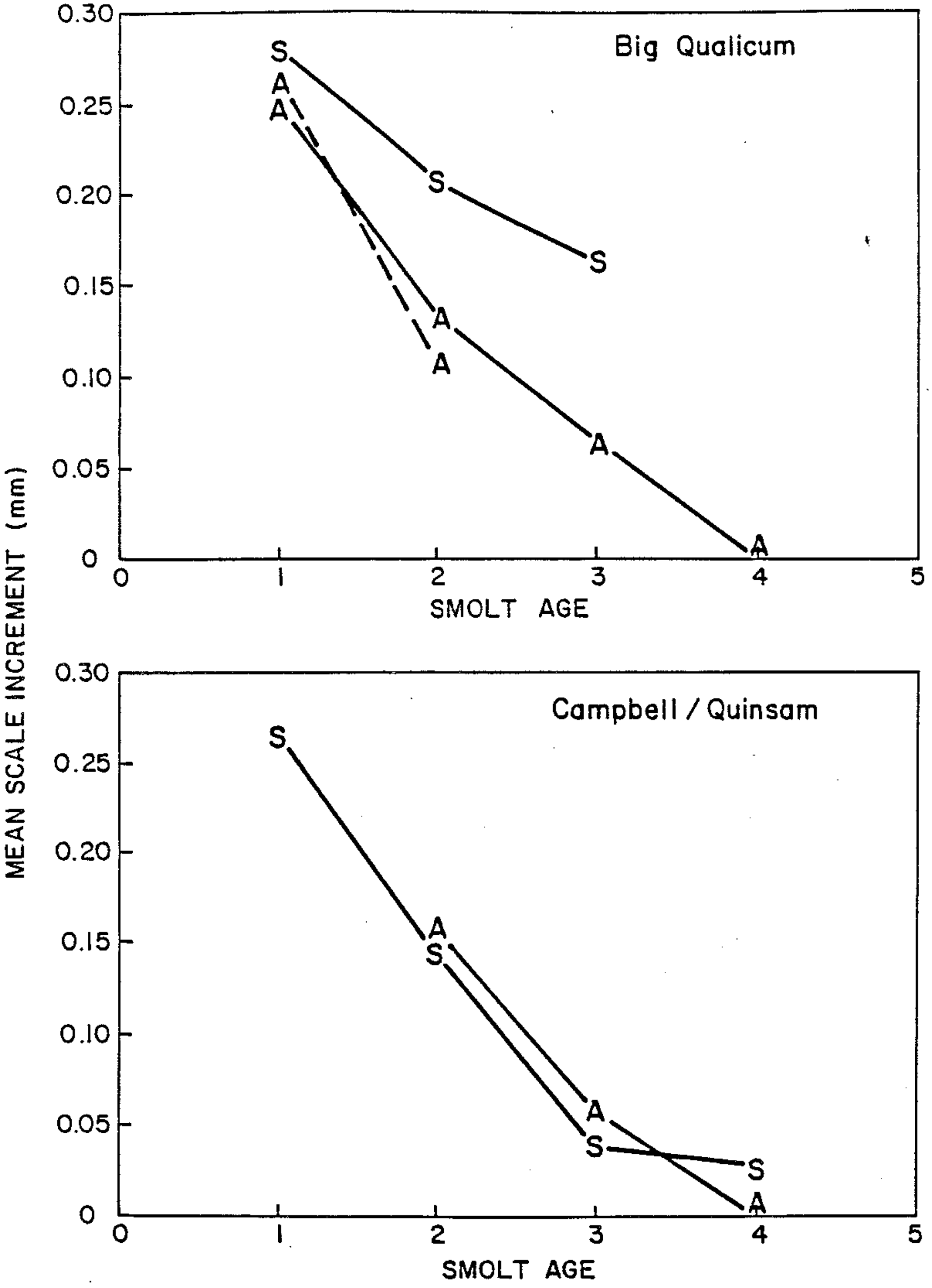

Fig. 5. Freshwater marginal scale increment (growth from last freshwater annulus to the edge of the freshwater zone) for wild (________) and hatchery (--------) steelhead smolts (S) and adults (A) sampled from the Big Qualicum and Campbell/Quinsam rivers.

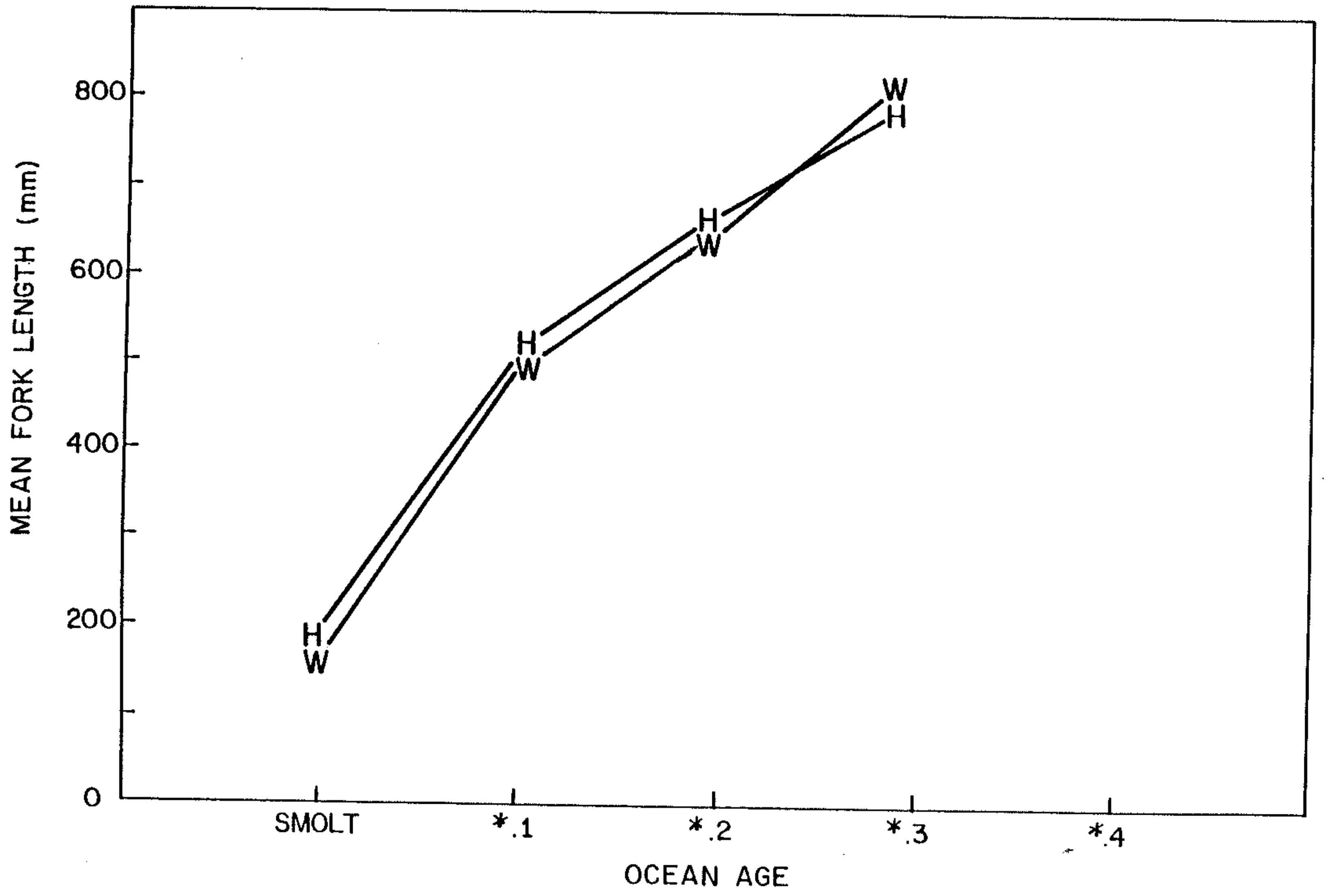

Fig. 6. Back-calculated mean fork lengths of wild (W) and hatchery (H) adult winter run steelhead collected from Vancouver Island streams and hatcheries. Freshwater ages are pooled for each ocean age.

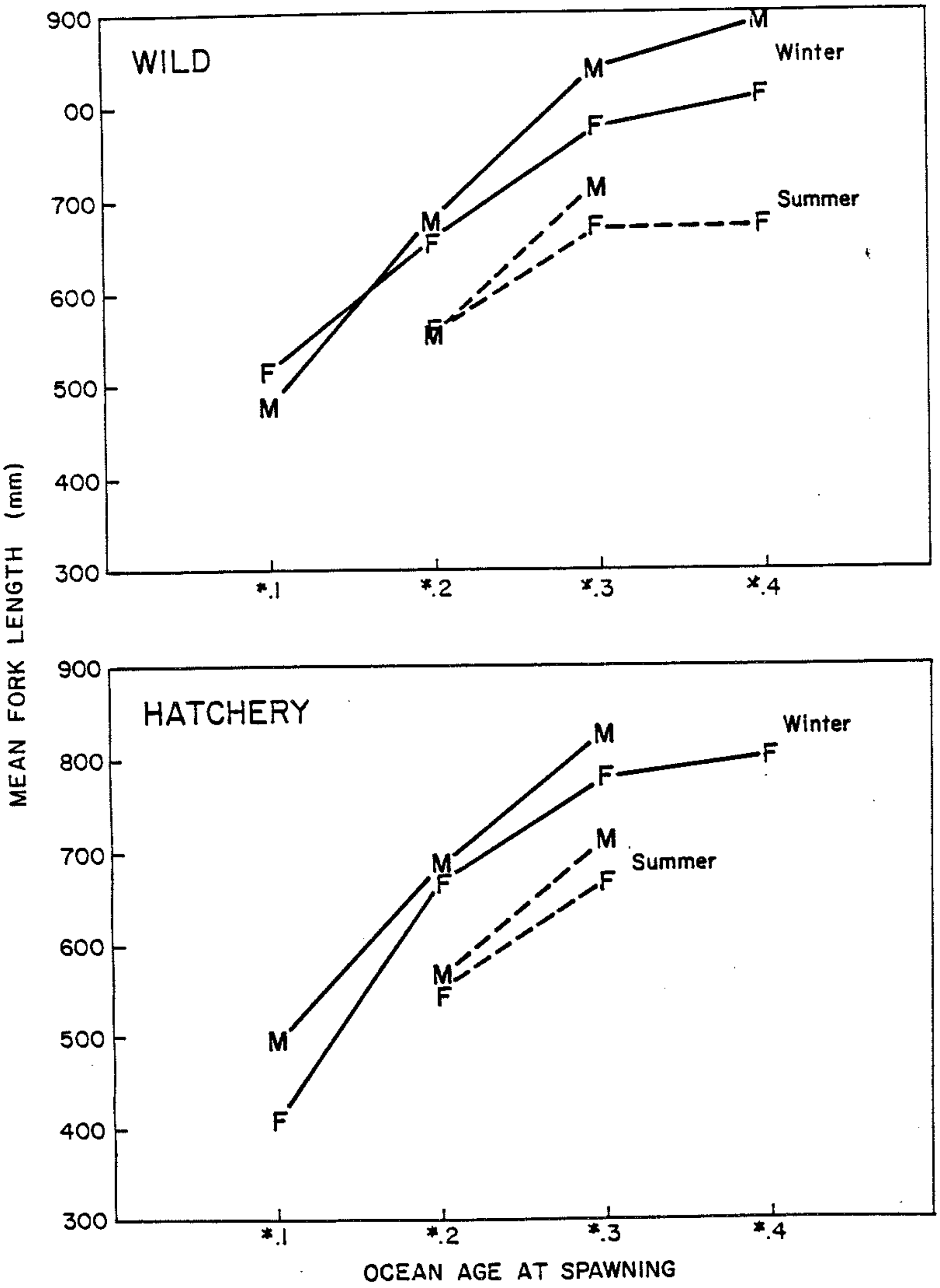

Fig. 7. Measured fork lengths of male (M) and female (F) winter and summer run steelhead trout collected from Vancouver Island streams and hatcheries. Freshwater ages are pooled for each ocean age.

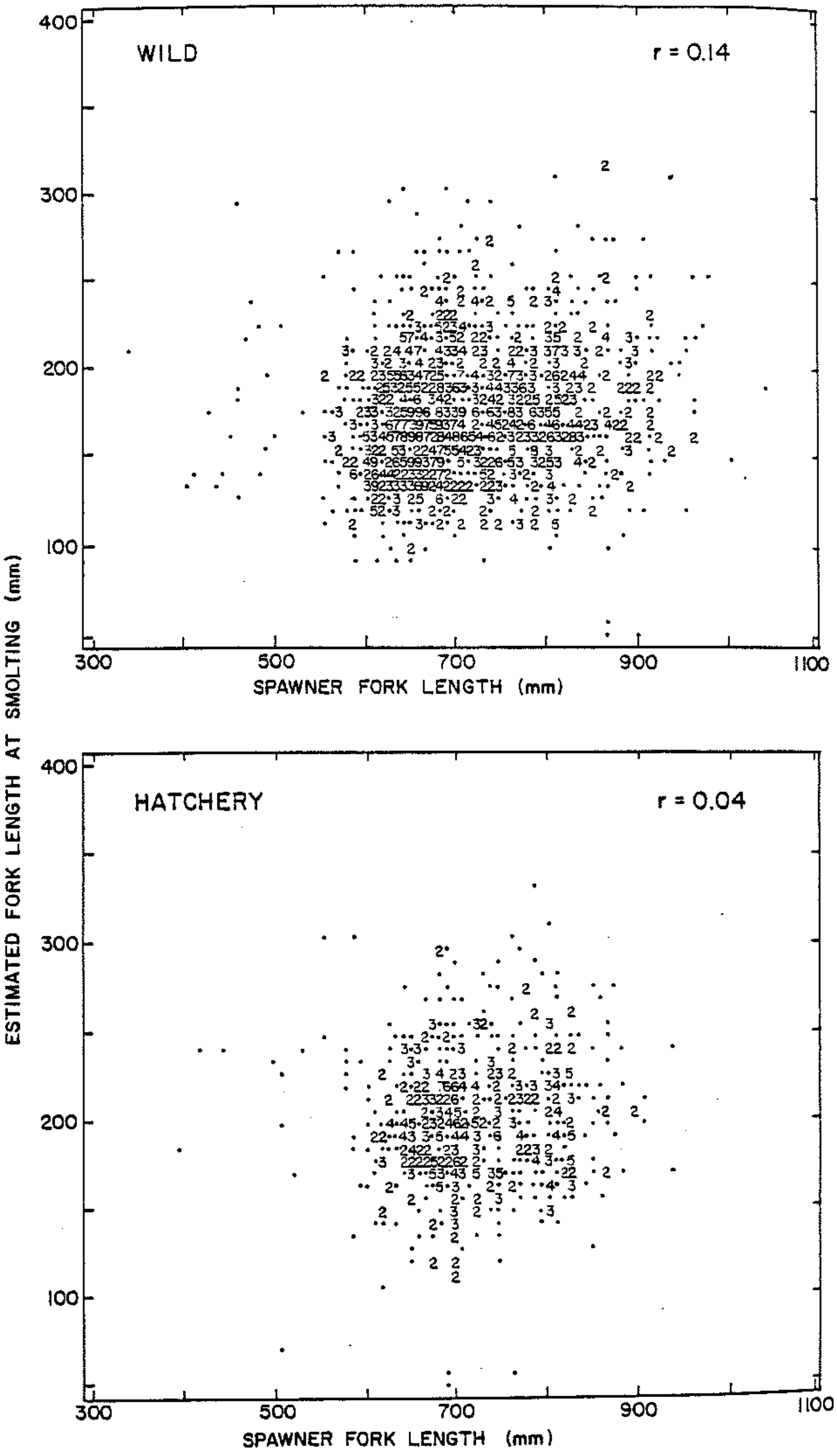

Fig. 8. Relationship between back-calculated length at smolting and measured length of adult wild and hatchery winter run steelhead trout returning to Vancouver Island streams between 1952 and 1982. Data points may represent more than a single frequency.

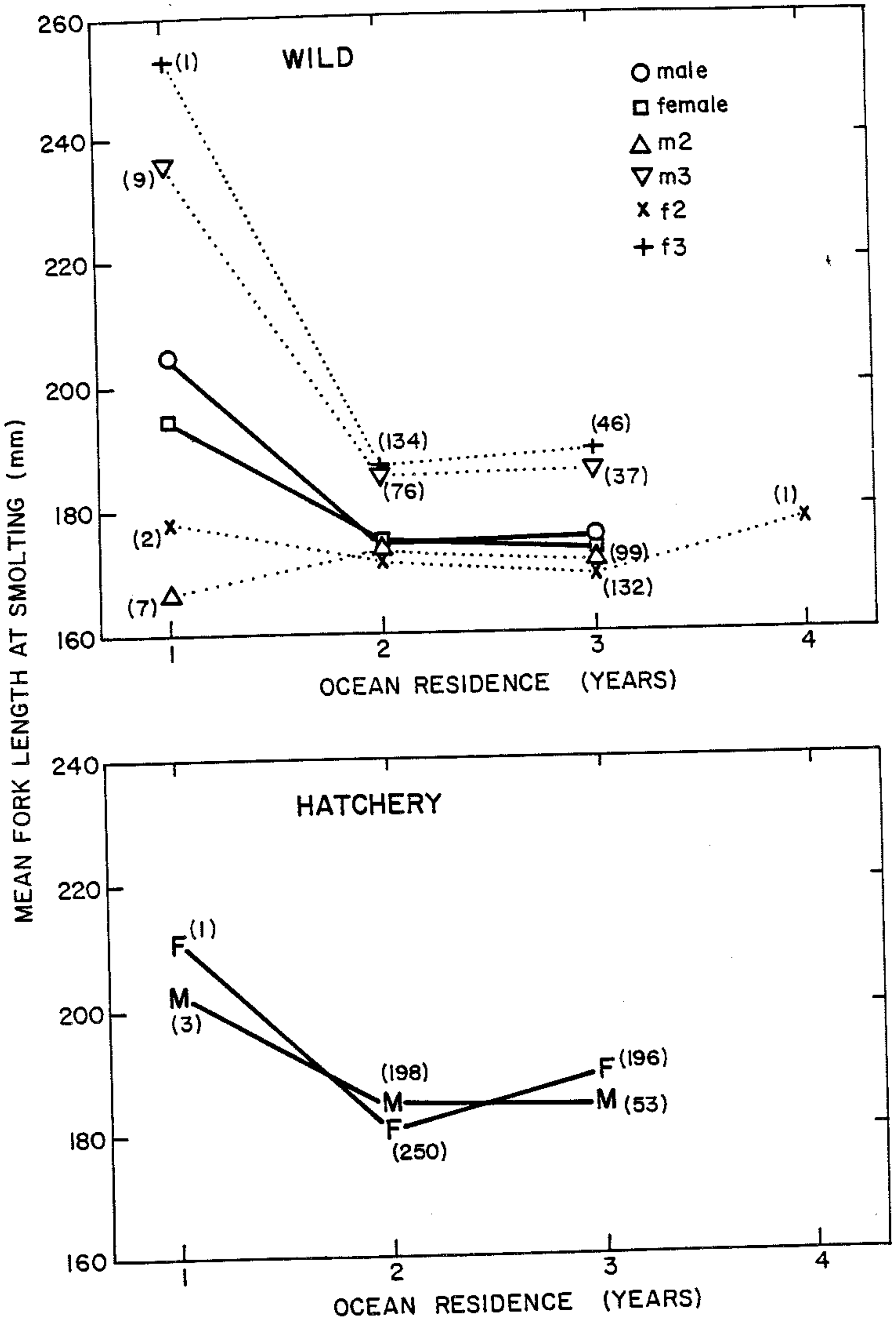

Fig. 9. Relationship between mean back-calculated length at smolting and ocean residence of winter run steelhead collected from Vancouver Island streams, 1952 to 1982 (m2 = male smolt, age 2; m3 = male smolt, age 3; f2 = female smolt, age 2; f3 = female smolt, age 3). Numbers indicate sample sizes.

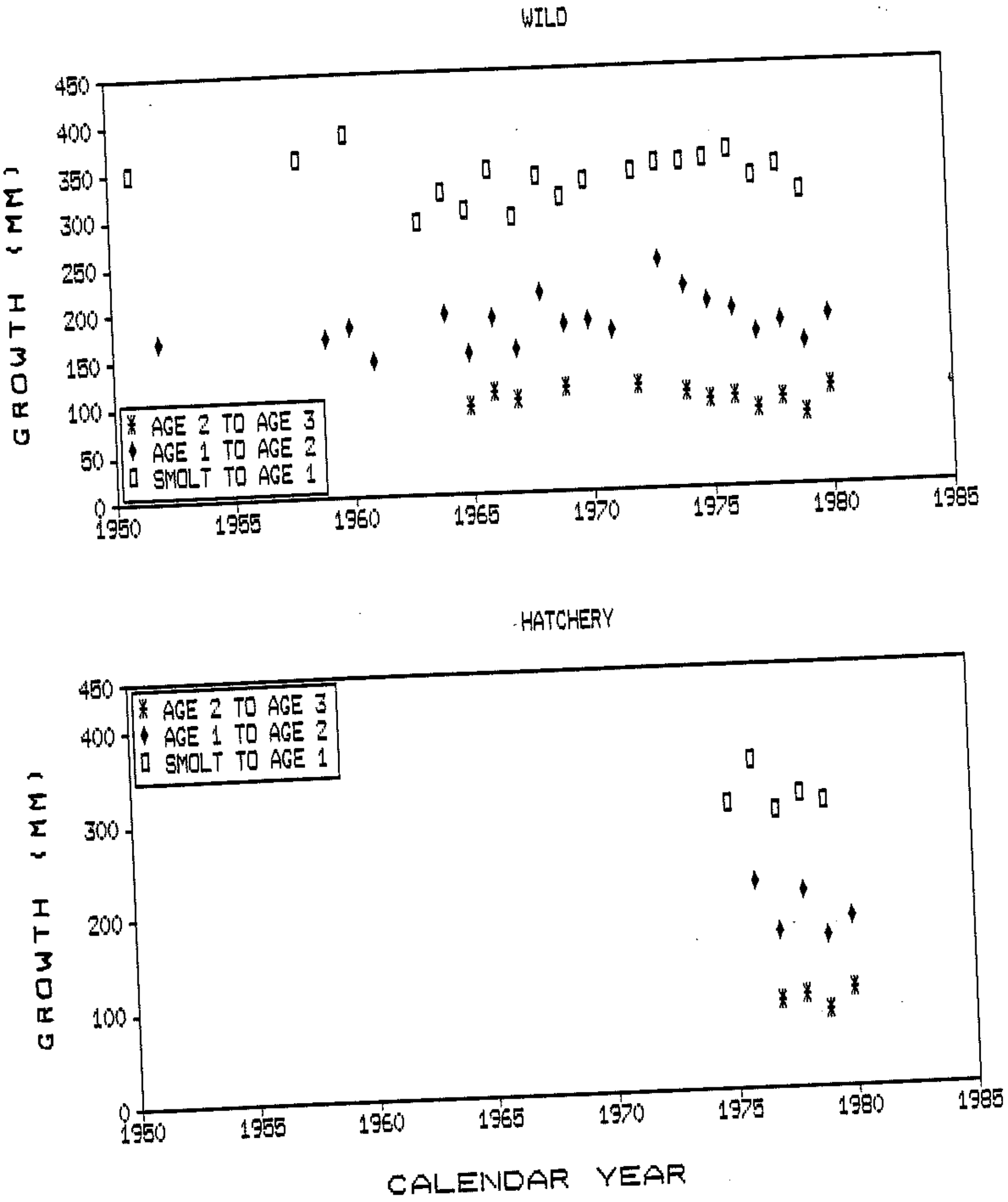

Fig. 10. Marine growth from back-calculated fork lengths of wild and hatchery winter run steelhead at smolting and at the end of each year of ocean residence between 1950 and 1982. Each data point is the mean of a minimum of 10 samples (range 10 to 215).

List of previous Fisheries Technical Circulars

1986	70	Dixon, B.M. Age, Growth, and Migration of White Sturgeon in the Nechako and Upper Fraser Rivers of B.C.
1986	71	Billings, S.J. Steelhead Harvest Analysis, 1984-85.
1986	72	Carswell, L.B., R.S. Hooton and V.A. Lewynsky. Campbell/Quinsam River Creel Surveys, 1975-76 to 1979-80.
1986	73	Clark, B.J. and A.R. Facchin. The 1984 Chilliwack-Vedder River Steelhead Creel Survey.
1986	74	Lirette, M.G., R.S. Hooton and V.A. Lewynsky. Preliminary Steelhead Production Capability Estimates for Selected Vancouver Island Streams.
1986	75	Tsumura, K. and J.M.B. Hume. A Comparison of Precociousness in Three Graded Size Classes of Hatchery-Reared Rainbow Trout (*Salmo gairdneri*).
1987	76	Billings, S.J. Steelhead Harvest Analysis, 1985-86.

List of previous Management Reports

1984	82	Martin, A.D. and J.M. Bell. Effects of 2.5 Year Closure of the Cutthroat Fishery on the Upper St. Mary River: Management Implications of Implementing an Alternate Year Closure on East Kootenay Trout Streams.
1984	83	Parkinson, E., R.J. Behnke and W. Pollard. A Morphological and Electrophoretic Comparison of Rainbow Trout (*Salmo gairdneri*) Above and Below Barriers on Five Streams on Vancouver Island, B.C.
1985	84	Hooton, R.S. A Questionnaire Survey of Vancouver Island Steelhead Anglers' Opinions and Preferences on Management Issues.
1985	85	Hooton, R.S. and V.A. Lewynsky. Big Qualicum River Steelhead Fishery Investigations, 1976 to 1981.
1986	86	Hooton, R.S. & M.G. Lirette. Telemetric Studies of Winter Steelhead, Gold River, 1982-83.
1986	87	Parkinson, E.A. Skaha Hatchery Evaluation.
1987	88	Tsumura, K., J.M.B. Hume and B.M. Chan. Effects of Size at Release in Rainbow Trout (*Salmo gairdneri*) Stocked in a Winterkill Lake.