Matchett

D. Pflug
Personal
Copy

Skagit River Rainbow Trout Population Trends: Research Angling from 1986 to 1994

by
Jeff A. Burrows
Ross Neuman

British Columbia Ministry of Environment, Lands and Parks
Fish and Wildlife Management
Surrey, B.C.

Regional Fisheries Report No. LM169
1995

ABSTRACT

Burrows, Jeff A and Ross Neuman 1995. Skagit River rainbow trout population trends: research angling from 1986 to 1994. B.C. Ministry of Environment, Lands and Parks Regional Fish. Rep. No. LM169, 15p.

Research anglers sampled Skagit River rainbow trout in 1986, 1987, 1990, 1992, and 1994. After controlling for the effects of river location and season, analysis of rainbow trout mean length revealed a stable mean of roughly 320mm for 1986-1992 followed by a decrease of 15mm in 1994. Catch per effort increased by roughly 2.4 times in 1994 relative to the previous years. We suggest that the increase in CPUE is the result of a change to catch-and-release regulations in the Skagit River in 1992, and that several hypotheses compete to explain the decrease in length. Future angling may reveal this to be a temporary length decrease. The rate of damaged maxillaries on rainbow trout (6-10%) indicates that catch-and-release is successfully providing recycled fish to the sport fishery. We recommend that the research angling program continue.

ACKNOWLEDGEMENTS

Thanks for

- funding this report: The Skagit Environmental Endowment Commission
- fishing: Ron Gellner, Poul Bech, Gil Sage, H. Colivas, M. Milko, A. Soprovich
- discussing Skagit River and Ross Reservoir trout: Alan Looff
- editing and analysis suggestions: Poul Bech

INTRODUCTION

As part of management research on the rainbow trout fishery of the Skagit River, the B.C. Fisheries Branch has implemented a small research angling program. Research angling took place in 5 of the last 9 years: 1986, 1987, 1990, 1992, and 1994.

The objective of this report is to examine trends in time and space of the abundance and size distribution of rainbow trout in the Skagit River, as this research angling has revealed. First we describe the general methods of the sampling program, then provide an analysis and summary of the data and discuss its implications. We end with some conclusions and recommendations.

METHODS

Descriptions of the Skagit River itself exist in detail elsewhere (for example, Neuman 1988).

Information anglers collected comes from 5 years of research: 1986 (data in Scott 1986), 1987 (Hickey and White 1987), 1990 (Bech 1991), 1992 (Gellner 1992), and 1994 (Burrows and Gellner 1995).

In 1986 biologists divided the Skagit River and its major tributary, the Sumallo River, into four fishing zones which a research angler could reasonably cover in a day (Scott, 1986). For recording capture locations, each zone had further divisions of reaches ranging 750-1000m in length (Fig. 1).

Anglers then fished the river on a variety of dates each year, although July through September was the focus (Fig. 2). Anglers sampled fish for species, river location, date, length (only those >250mm in 1990-1994), and subsampled scales, at a minimum. Choice of river location was relatively uniform although the Sumallo River received effort only in 1986 (Fig. 3). Anglers used a mixture of bait, artificial lures, and flies to catch fish, but from the 1986 data it is clear that different gear did not bias the sampled length distribution of fish (Fig. 4).

Less consistently the anglers sampled the following: sex (external observation), apparent condition, parasite presence, maturity, and signs of previous capture. We will not consider all of these factors here, but the data is on file with the fisheries branch, as are the scale samples which also remain a source of information that biologists can examine.

Effort in hours was not consistently recorded; it proved convenient for us to use one fishing day as the unit of effort, and we assumed that on each recorded day one angler fished (=one research angler-day).

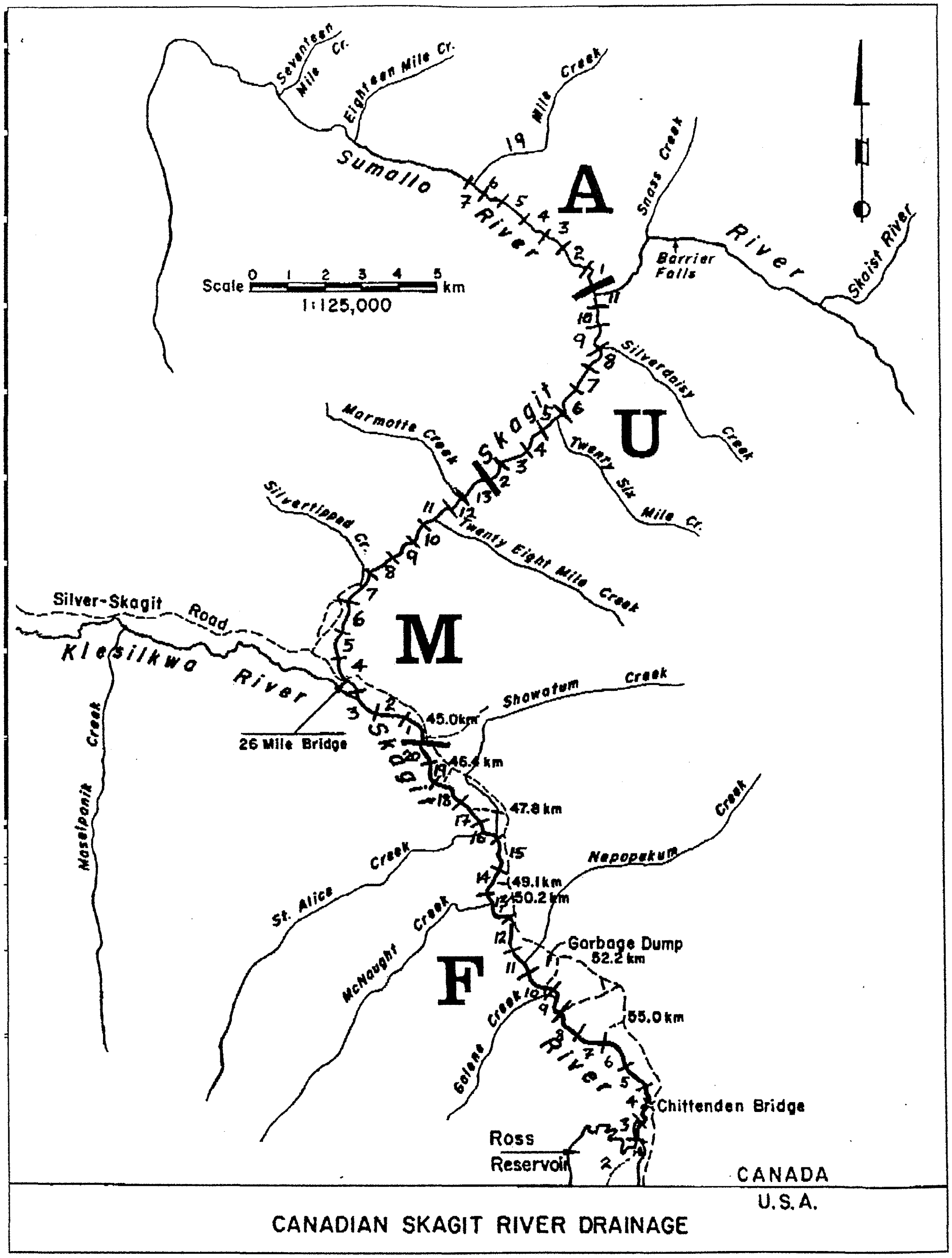

Fig.1. Skagit River research angling sampling sites. In this report we refer to the Sumallo ("A"), the upper Skagit ("U"), the middle Skagit ("M") and the lower Skagit ("F"). Each zone has smaller numbered subdivisions of 750-1000m to identify capture location.

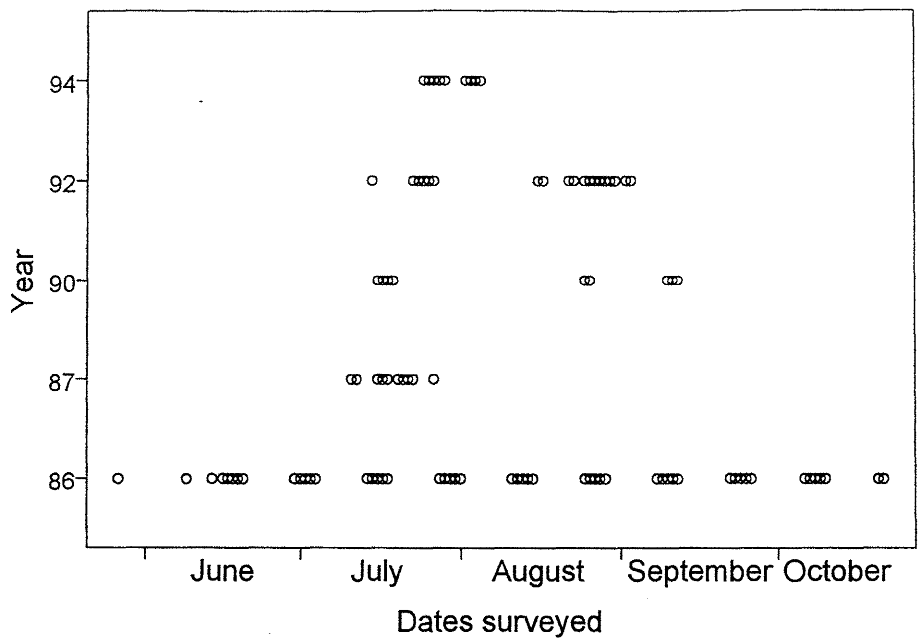

Fig. 2. Dates surveyed by year. July through September has been the focus.

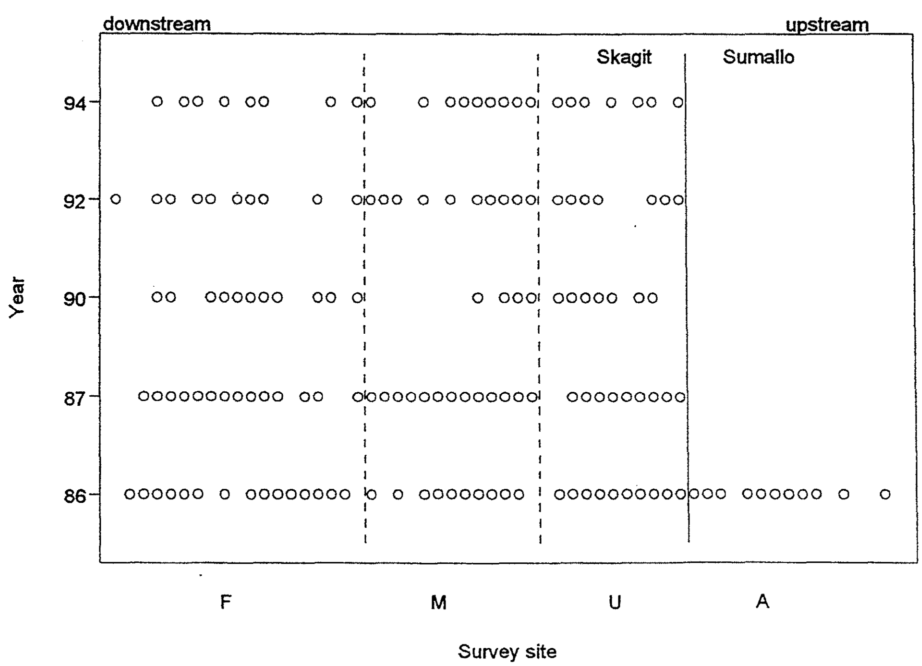

Fig. 3. Survey sites angled by year. Coverage was fairly even; the Sumallo (A) was surveyed only in 1986. See Fig. 1 for site boundaries (F=lower Skagit, M=middle Skagit, U=upper Skagit)

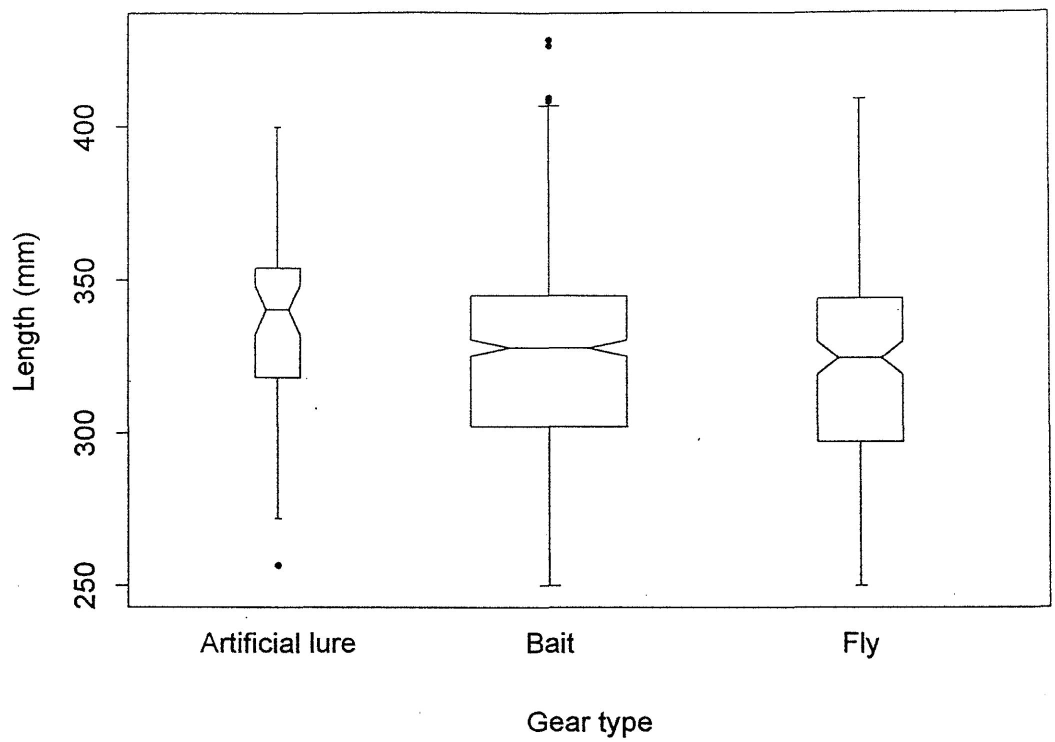

Fig. 4. Boxplot[1] summaries of rainbow trout length distributions (>250mm) with different types of gear in 1986 (the only year with explicit gear per fish information). Non-overlapping notches would indicate a statistically significant difference between the medians of any given pair of distributions, at roughly the 5% level. Although bait may catch a few larger trout, in general it appears that there is no important difference in the distribution of fish angled.

RESULTS

I. Patterns of length distribution in time and space

We show histograms of rainbow trout lengths in Fig. 5, omitting those less than 250mm in length because only the 1986 and 1987 angling programs recorded them, after which (1990 and on) only fish of immediate interest to recreational anglers were sampled. Differences in the season and location of sampling allow only a few simple inferences: inspection suggests that the length distributions aren't normal and that there are at least two or more length modes in each year. Presumably these correspond to age classes. Examination of scale samples on file would more precisely specify the length at each age (growth), as well as the age structure of Skagit River rainbow trout through time.

[1] These boxplots show the median as a line dividing the box, 75th and 25th percentiles as the top and bottom of the box, outliers (>1.5× inter-quartile distance from each quartile) as points, and the range as vertical lines (excluding outliers). Box widths are proportional to √sample size.

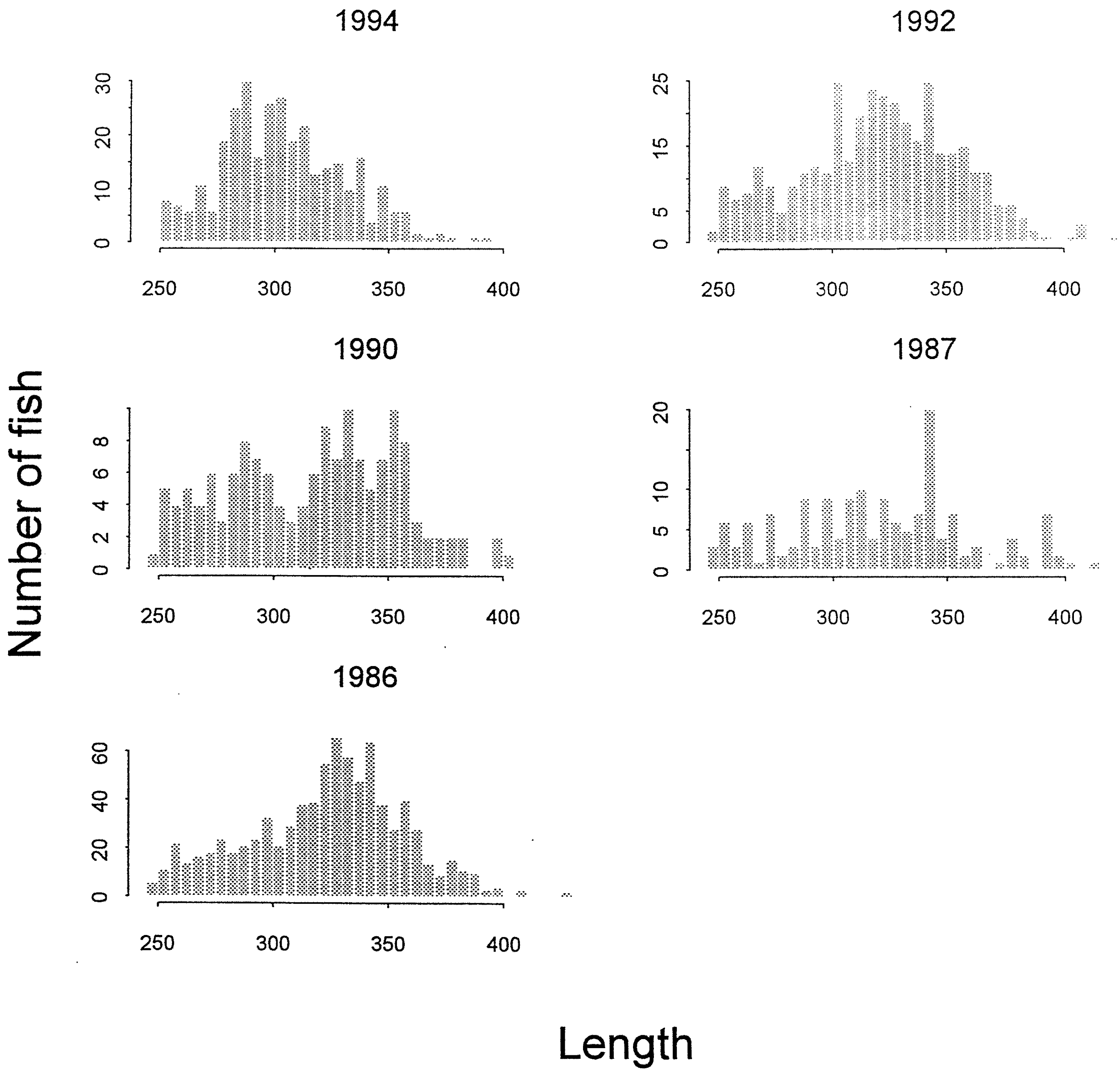

Fig. 5. Length histograms showing the distribution of angled trout lengths by year. These distributions are not very comparable due to differences in sampling season and locations, but two or three age classes are generally apparent as modes. Lengths less than 250mm were excluded for the two years where they were measured (1986, 1987).

Fig. 6. Length distribution (>250mm) summaries by zone (see Fig. 1) and year. The boxplots show that there is a trend to larger fish as one moves upstream, except for the one Sumallo sample (1986 a). This is most clearly apparent in 1986, 1987, and 1994, whereas the other pair of years are ambiguous. There are reasonable grounds for stratifying sampling and analysis based on location. Two plausible explanations for this size pattern are: larger fish may spawn farther upstream, and remain to feed, or feeding migrations of smaller fish from the reservoir into the lower part of the river may occur.

Since there were several-month long ranges in sampling date and up to 30km differences in sampling location, it seemed reasonable to examine what effects season and location had on length distributions.

Boxplots in Fig. 6 show that there is a trend to larger fish as one moves upstream, except for the one Sumallo sample (1986 a). This is most clearly apparent in 1986, 1987 and 1994; 1990 and 1992 show no pattern. Nevertheless there are good grounds for stratifying sampling and analysis based on river zone. Differences in median length are not large: the difference in median length between zones ranged from 3mm (1992) to 21mm (1987). Table 1 summarizes median length by zone and year. Likely explanations for this relatively consistent pattern are that larger fish migrate farther upstream to spawn, and remain to feed through the summer, or that feeding migrations of smaller fish into the lower reaches occur. These differences in length are trivial from an angler's perspective.

Table 1. Median rainbow trout length (mm) stratified by zone and year. Sample size (no. trout) in brackets. NA = not available.

Year	Lower	Middle	Upper	Sumallo
1986	325 (443)	329 (209)	338 (127)	329 (54)
1987	311 (53)	315.5 (56)	332 (51)	NA
1990	325 (90)	320 (7)	321 (52)	NA
1992	322 (206)	325 (69)	325 (96)	NA
1994	300 (167)	303 (99)	307 (59)	NA

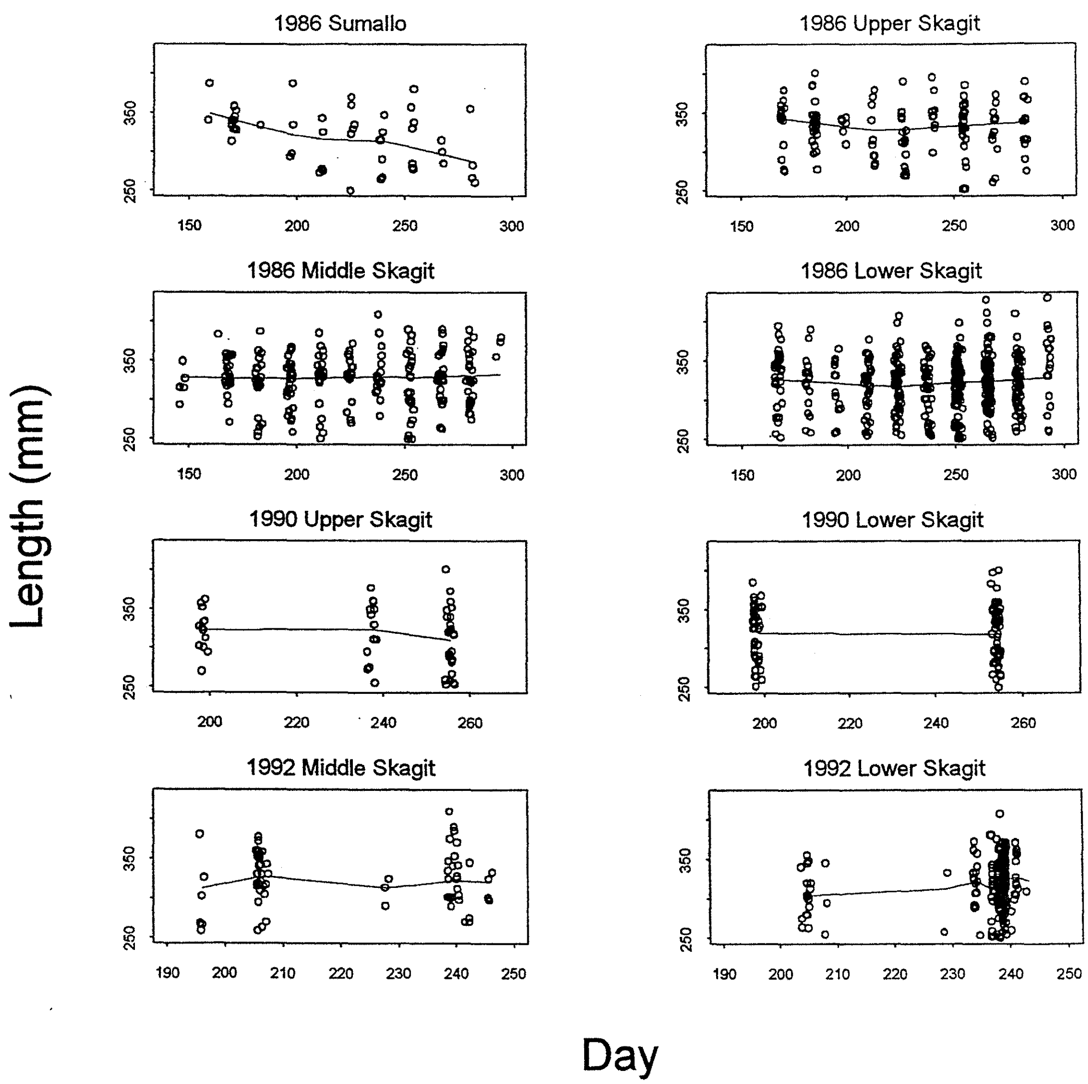

Fig. 7. Length samples versus day of the year caught, for river zones and years where more than a few weeks of seasonal contrast is available. Lines are locally weighted regressions. Only the Sumallo in 1986 showed any clear trend in size (decreasing in this case probably due to emigration). Note that time scales are the same within but not between years. We would expect to see some growth over these time periods in a closed population but see none or very little; presumably the effect of larger fish leaving the river for the reservoir or smaller fish moving into the river from the reservoir is masking growth.

Plots of length versus day of year show that within a year there is no trend in size, in general (Fig. 7). The 1986 Sumallo sample is the only exception: size decreased steadily over the sampling season possibly as a result of Ross Reservoir spawners emigrating downstream (Rosenau and Slaney 1991) but more likely as a result of smaller fish immigrating from the Skagit (Fig. 8). Since we would expect to see growth over the time periods we graph, but don't, fish moving into and out of the open Skagit River population are probably hiding growth. Perhaps larger fish are gradually returning to Ross Reservoir, but tagging studies indicate that there is little movement of trout during the summer (Usher 1986). Fig. 8 explores the possibility that fish movements are masking growth. Although it is not possible from these data alone to estimate growth rates, examination of trout scales on file will reveal growth via back-calculation procedures.

We finish our summary of length patterns with an analysis of length trends from 1986-1994 (Fig. 9). After excluding pre-July and post-August samples to control for any seasonal effects which may exist (although the plots in Fig. 7 revealed no obvious trend), we see that trout length has been stable with both means (summarized in Table 2) and medians (Table 1, Fig. 9) in the range 300-335mm. However, rainbow trout in 1994 were clearly sampled from a smaller distribution, with the overall mean (306mm) 15mm shorter than the mean of the other 4 sample years (321mm). We note that the Skagit River sport fishery shifted from a 2 fish daily limit to catch-and-release in 1992. Hypotheses which might explain this size decrease include:

- more larger fish being killed in the Ross Reservoir fishery (but average size of angler harvested fish has varied only 4mm, from 331-335mm, during the period 1990–1994 - Looff 1992, 1993, 1994, 1995ab)
- a general deterioration of growth conditions in the Skagit-Ross system,
- or increased survival of smaller fish in either the Skagit River, Ross Reservoir, or both.

II. Catch patterns

We estimated catch-per-unit-effort for each year of research angling, as the annual mean number of trout recorded on all dates, assuming one angler per date (which gave trout per angler day as the unit). Fig. 10 shows a relatively stable CPUE of approximately 15 trout per day in the first 4 sample years, jumping remarkably by almost 2.5 times to 36 trout per day in 1994. New regulations for Ross reservoir in 1990 and the Skagit River in 1992 are the likeliest explanation for this change, and since the change from 1992 to 1994 is much higher than 1990 to 1992 it seems likely that the new catch-and-release regulation on the Skagit River in 1992 had the strongest impact on CPUE.

Data from the Ross Reservoir creel survey (Looff 1992, 1993, 1994, 1995ab) roughly corroborate this change in CPUE. The number of rainbow trout caught per hour at the north end of the reservoir has increased each year since 1991. The movement of trout between the reservoir and river make it likely that whatever the reason for the increased CPUE in the river, it is the same reason for increased number of trout caught per hour in the reservoir fishery.

Higher catch rates suggest higher fish densities, and higher fish densities suggest another hypothesis to explain the decrease in mean and median size of rainbow trout in the river: higher densities may be slowing growth rates.

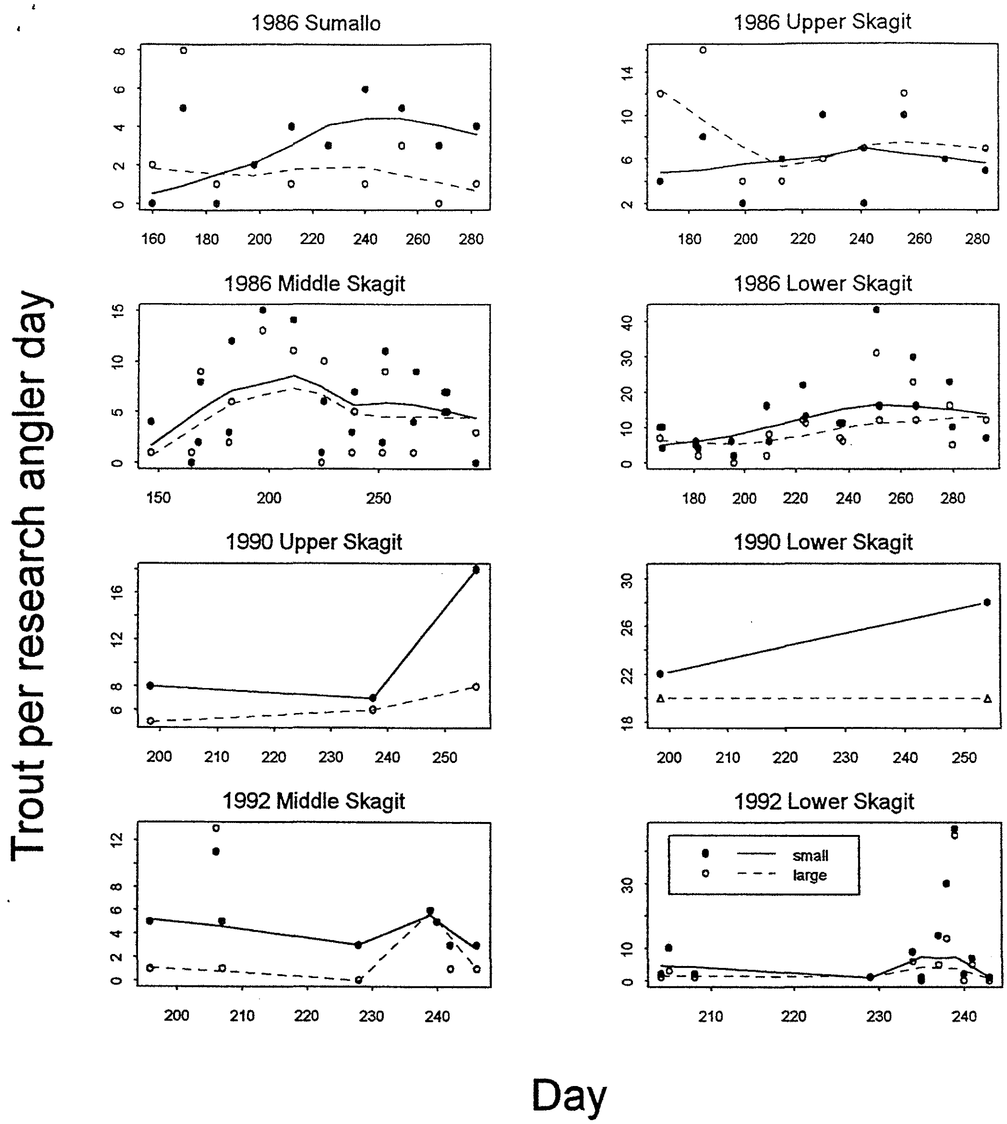

Fig. 8. CPUE versus day of the year for the same river zones and years as in Fig. 7. We show CPUE for two size classes of fish (legend in last panel refers to all plots; small means up to 330mm, large above 330mm), in order to examine the role that changing abundance numbers of smaller or larger fish might play in masking the growth rate over time. The Sumallo decline in length (Fig. 7) is clearly a result of larger numbers of smaller fish present in the catch (top left panel). Larger fish left the upper Skagit in early 1986 (top right panel), and in 1990 both the upper and lower Skagit saw increases in the number of smaller fish, suggesting either migrations of smaller fish into those river zones or large numbers growing into the fishery (>250mm) between sample dates. Thus we see some evidence for fish movements into or out of the Skagit during the fishing/sampling season, although Usher (1986) noted a lack of movement of tagged fish during the summer months.

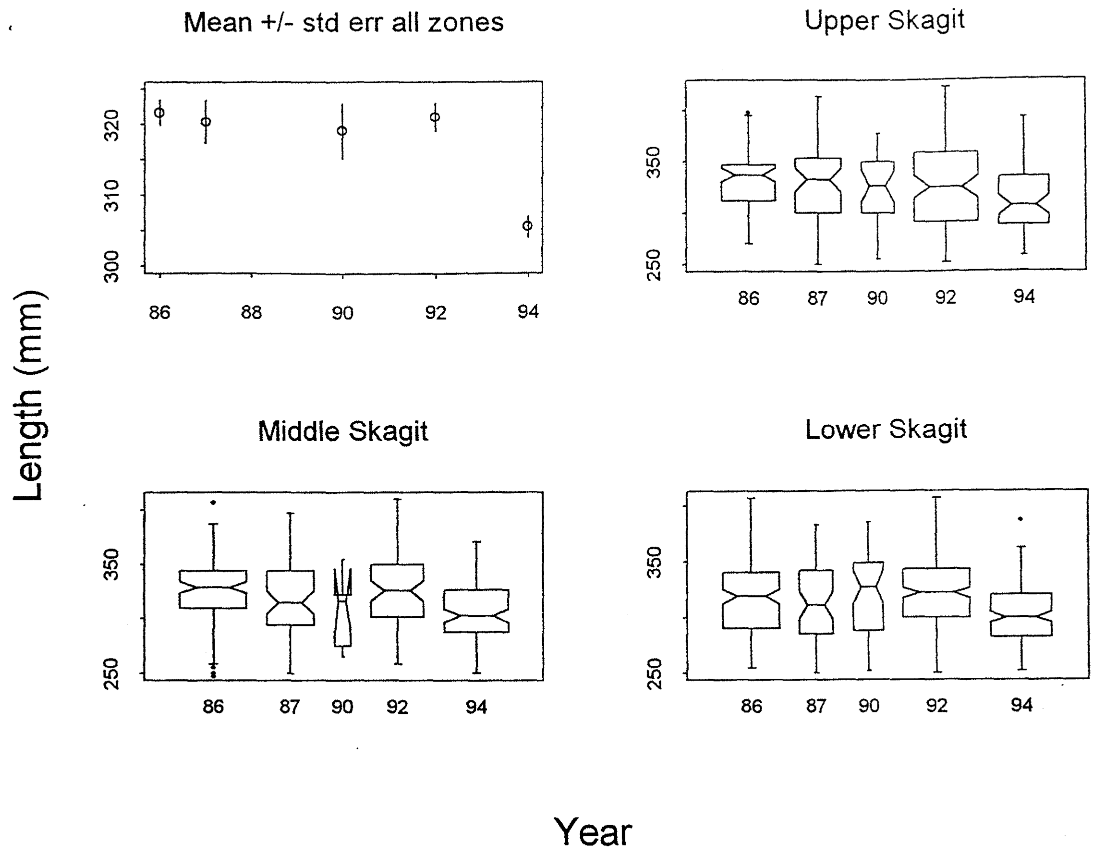

Fig. 9. Annual trend in rainbow trout size using only July and August (lengths >250mm) to minimize whatever small seasonal effects there may have been on length (in 1992 the only available data for the upper Skagit were from September). The first panel shows that 1994 is mildly anomalous at a mean of 306mm, in contrast to a running mean of 321mm based on the previous 4 sample years. The boxplots show the large overlap in distributions, and that the median length was also smaller in 1994 than in previous years in all fishing zones. Note that significant regulation changes occurred: in 1990 Ross Reservoir regulations change to 3 fish per day limit (from 4), 330mm minimum size (from no minimum size) and a bait ban (no gear restrictions previously) and in 1992 Skagit River regulations changed to entirely catch and release from a 2 fish limit per day. Several hypotheses compete to explain the smaller 1994 lengths (see text).

Table 2. Rainbow trout length (mm) statistics. Overall mean length as well as stratified by river zone. To control for possible seasonal effects these statistics are based on July-August samples only (overall maximums for 1986, 1990 and 1992 were 430mm, 401mm, and 422mm respectively).

Year	Mean	Max	Std. Dev.	No. Fish	Upper	Middle	Lower
1986	322	409	33	342	332	325	316
1987	320	413	39	160	331	320	311
1990	319	385	34	74	322	308	319
1992	321	410	32	271	324*	326	320
1994	306	392	27	325	313	306	303

*Sept.

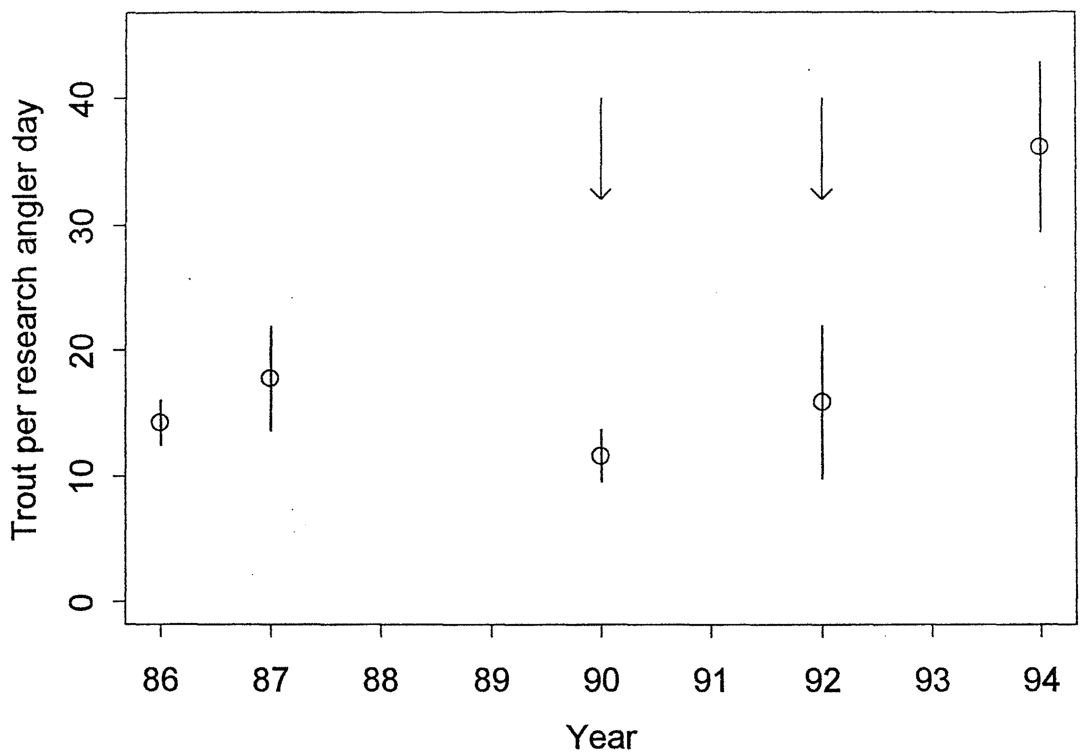

Fig. 10. Mean number of trout per research angler day (± standard error; the sample was the number of trout caught on a given day) for various years. Only trout > 250mm in length caught in July and August were considered, to make years comparable (Sumallo angling included for 1986; excluding Sumallo data increases the 1986 rate by only 2.5 fish per day). The arrows show years when important new regulations came into force: in 1990 Ross Reservoir regulations changed to 3 fish per day (from 4), 330mm minimum size (from no minimum size) and a bait ban (no gear restrictions previously). In 1992 Skagit River regulations changed to entirely catch and release from a 2 fish limit per day. All other things being equal (for example, that an average angler day is essentially the same unit of effort among the years and anglers), the catch and release regulation clearly had a large impact. Mean research angler catch in 1994 was 2.4 times as high as the average of the other research years. It was not clear in the data reports for 1990 and 1987 whether or not anglers fished on separate days or on the same day: if the latter the estimates we show are too high, making the increase in 1994 catch per unit effort all the more significant. Daily trout totals from other years were clearly from a single angler, and should be unbiased.

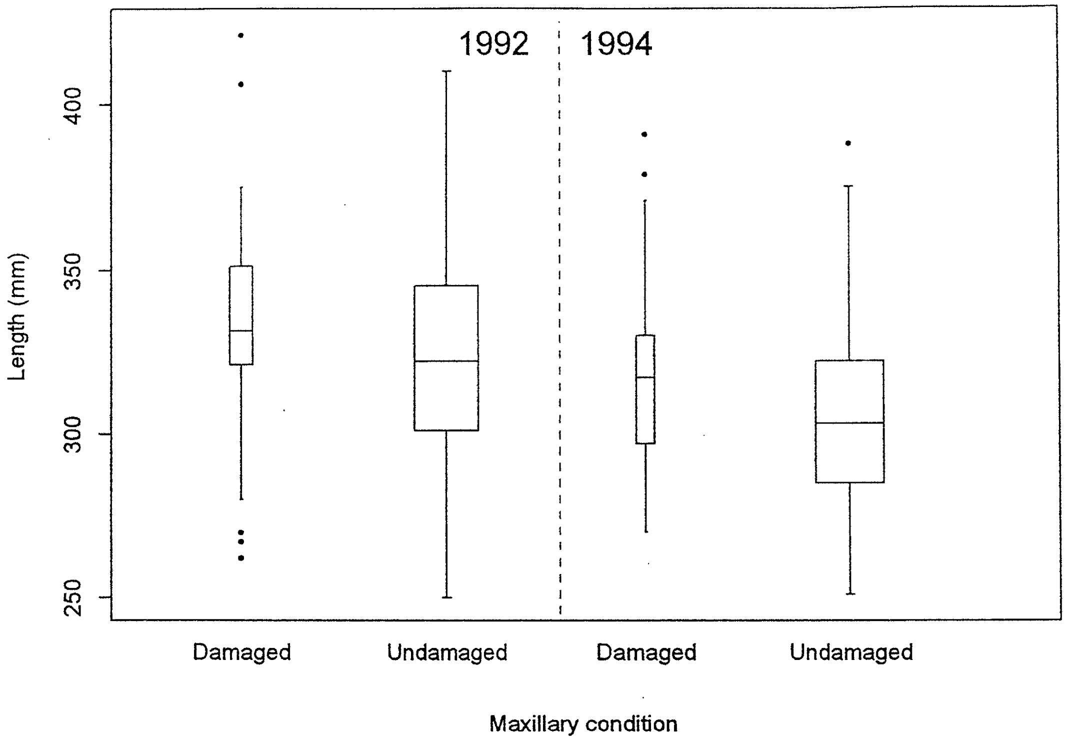

Fig. 11. Boxplots contrasting the fork length of rainbow trout with damaged maxillaries for 2 years of research angling. Anglers occasionally damage the bone when releasing trout. Most anglers manage to release trout without permanently deforming a maxillary bone, so even the low rates of damage we observe, 10.1% in 1992 (32 damaged, 284 undamaged) and 6.5% in 1994 (21 damaged, 304 undamaged), indicate a high rate of "recycling." That damaged fish tend to be slightly larger (10-15mm) provides support that it is angling causing the damage: longer means older and therefore vulnerable to angling for a longer period of time, on average.

As a final comment on the impact of the 1992 vintage catch-and-release regulation, Fig. 11 shows the length distribution of rainbow trout with and without damaged maxillary bones for two research angling years. The high rate of damage (6-10%) likely implies a higher rate of "recycling" of trout; that is, anglers are successfully releasing trout which other anglers are then catching. Fish with damaged maxillaries tend to be 10-15mm longer and are therefore slightly older, and have been vulnerable for that much longer.

DISCUSSION

It has proven useful to stratify sampling by location because in the majority of sampling years there have been differences in length among zones and even an up- to downstream pattern of larger to smaller fish (although these size differences were never very large).

Less clear has been the utility of a long sampling season and probably the trend in the last few years to limit research angling to the summer makes sense, since no within-season patterns in length revealed themselves with the single unrepeated exception of the Sumallo River, and research angling may as well limit itself to the fishing season (currently July 1 to October 31).

The response of a river trout population to the institution of catch-and-release angling regulations has been typically a strong increase in catch per unit effort and increases in the size of trout that anglers land (the classic example being Yellowstone National Park - Jones 1987, for example). We see hints of this response in the Skagit River (and possibly the north end of Ross Reservoir) in that there was a strong increase in trout per research angler day (and trout caught per hour in the Ross fishery), but paradoxically a decrease in the size of trout caught in the river, both correlated with the new catch-and-release regulation. Why would we observe one hallmark but the opposite of the other? We suggested several hypotheses when analyzing the results:

1. Density dependent growth rate decrease in response to higher trout densities
2. General deterioration of growth conditions in the Skagit-Ross system
3. No growth change but higher cropping of larger fish in the Ross Reservoir kill fishery
4. Higher survival rates of smaller fish in the Skagit River and Ross Reservoir, with a strong year class moving through the 1994 fishery

Another one is that the size decrease, though statistically significant, is too small (15mm) to be important and may in fact be temporary: the next research angling season may reveal it to be so.

Examination of scales to compute individual growth rates for different size classes and years should provide a means for distinguishing among these hypotheses. The fact that mean length has not decreased in the last five years of the Ross Reservoir fishery suggests that the third hypothesis is less likely than the fourth.

Angler comments during the 1994 Ross Reservoir creel survey indicated surprise at the general thin condition of the rainbow trout in comparison to memories of trout they caught in other years (J. Burrows, pers. observation), providing some support for the notion that growth conditions have lately declined.

The high rates of damaged maxillaries on the trout of the Skagit River indicate that the catch and release angling regulation is providing more sport to river fishermen by recycling trout, some of which would otherwise have ended up in the creel, although river anglers may not realize that they now could be subsidizing a general increase in the catch per hour of the northern Ross Reservoir fishery, of which anglers harvest a fraction.

CONCLUSIONS AND RECOMMENDATIONS

- Trout size has remained stable since 1986, decreasing by a small amount in 1994.
- Catch-per-unit-effort has also remained relatively stable until 1994, when it more than doubled.
- The increase in catch rate is likely a result of the new catch-and-release fishery which began in 1992.
- Several hypotheses compete to explain the decrease in length in 1994. We can evaluate their relative likelihood by examining scale samples to back-calculate growth rates for individual trout and by sampling some indication of trout condition in the future.
- Further sampling will reveal if decreased size is a continuing phenomenon.
- The damaged maxillary rate indicates significant recycling of trout and therefore that the implementation of catch-and-release has been successful.
- In the future, research anglers should continue to evenly cover the river during the summer, and subsample weight or some other indication of condition, and record a standard angler day or hours fished, in addition to the standard data collection.
- Research angling has revealed important changes to the fishery likely resulting directly from regulation changes; therefore, it should continue as part of the fisheries branch's management efforts in the Skagit River system.

REFERENCES

Bech, P. 1991. Skagit River rainbow trout sampling program, 1990 data report. B.C. Ministry of Environment Regional Fisheries Report No. LM215, 6p.

Burrows, Jeff A. and Ron J. Gellner. 1995. Skagit River trout sampling program, 1994: data report. B.C. Ministry of Environment, Lands, and Parks Regional Fisheries Report No. LM034, 9p.

Gellner, R.. 1992. Skagit River rainbow trout sampling program, 1992 data report. B.C. Ministry of Environment Lands and Parks Regional Fisheries Report No. LM233, 11p.

Hickey, D.G. and I.W. White. 1987. 1987 Canadian Skagit River rainbow trout sampling program. B.C. Ministry of Environment Regional Fisheries Report No. LM135, 19p.

Jones, Ronald D. 1987. The Yellowstone experience: a decade of catch-and-release, p. 94-99 *In* R.A. Barnhart and T.D. Roelofs [eds.] Catch-And-Release Fishing: a Decade of Experience, Proceedings of a National Sport Fishing Symposium. Humboldt State University, Arcata.

Looff, A.C. 1995. Ross Lake rainbow trout study 1994-95 final report. Washington Department of Fish and Wildlife Fisheries Management Division, Skagit Environmental Endowment Commission Project Report No. 94-08, 95p.

Looff, A.C. 1995. Ross Lake rainbow trout study 1993-94 progress report. Washington Department of Fish and Wildlife Fisheries Management Division, Skagit Environmental Endowment Commission Project Report No. 93-11, 86p.

Looff, A.C. 1994. Ross Lake rainbow trout study 1992-93 progress report. Washington Department of Fish and Wildlife Fisheries Management Division, Skagit Environmental Endowment Commission Project Report No. 92-08, 93p.

Looff, A.C. 1993. Ross Lake rainbow trout study 1991-92 progress report. Washington Department of Wildlife Fisheries Management Division, Skagit Environmental Endowment Commission Project No. 91-07, 93p.

Looff, A.C. 1992. Ross Lake rainbow trout study 1990-91 progress report. Washington Department of Wildlife Fisheries Management Division, Skagit Environmental Endowment Commission Project Report No. 92-15, 95p.

Neuman, H.R.. 1988. Skagit River and Ross Reservoir fisheries management plan. B.C. Ministry of Environment Regional Fisheries Report No. LM150, 40p.

Rosenau, M.L. and P.A. Slaney. 1991. A population assessment and stocking evaluation of the rainbow trout in the Sumallo River. B.C. Ministry of Environment Fisheries Project Report No. 26, 82p.

Scott, K.J.. 1986. A data report of rainbow trout tagging and test fishing studies in the Canadian Skagit River, 1986. B.C. Ministry of Environment and Parks Regional Fisheries Report No. LM114, 68p.

Usher, J.B. 1986. Skagit River rainbow trout (*Salmo gairdneri*) tagging study, 1984. B.C. Ministry of Environment Regional Fisheries Report No. LM101, 28p.