BC Environment

Precision and Bias of the British Columbia Steelhead Harvest Analysis

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Skeena Fisheries Report SK122

July 1999

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ABSTRACT

The BC Steelhead Harvest Analysis (SHA) is a province-wide mail survey of steelhead anglers which has been conducted annually since 1967, to obtain estimates of effort and catch stratified by stream and residency. This study reports the compilation and examination of information relating to the accuracy of the survey. Objectives were to assess the capability of available data to reveal the precision and bias of SHA estimates, and to summarize how SHA results compare to steelhead fishery catch and effort parameter estimates from other sources.

Precision of SHA estimates was examined by bootstrap re-sampling of questionnaire responses for approximately 45 fisheries between 1983 and 1995. Precision varied substantially among resident classes, in part due to the higher mail-out proportion applied for non-resident anglers. At a given parameter level, precision also varied substantially between fisheries. Relative precision was highest for estimates of the number of participating anglers, and lowest for catch parameters. Resulting 95% confidence interval widths ranged from approximately twice the estimate value for the lowest estimate values assessed, to roughly one-third the estimate value in the best case for the highest estimates examined.

Bias was assessed through reanalysis of follow-up contact data from 1978/79 and 1982/83, along with preliminary examination of results from an intensive study on the Thompson River in 1984. First-mailing upward bias due to nonresponse was estimated at 24% for number of anglers, 59% for number of successful anglers, and 29% for retained catch, for province-wide aggregate data from the 1978/79 study. In 1982/83, aggregate data from Region 1 re-contact similarly suggested first-mailing upward bias due to nonresponse of 24% for number of anglers but only 33% for number of successful anglers. Water-specific results for 14 fisheries reported in 1978/79 imply first-mailing upward bias due to nonresponse of 20% for number of anglers, 24% for angler days, 29% for retained catch and 27% for released catch, with high variability between fisheries in apparent bias. The Thompson River 1984 study matched individual anglers' field survey results against their SHA questionnaire responses, and suggested that positive recall bias occurs due to angler memory exaggeration of effort and catch as well as angler assignment of activity to the wrong time period. However, rigorous statistical analysis of this dataset is needed to alleviate censoring of the data and allow unbiased estimates of recall effects along with nonresponse bias.

Ninety-five stream-specific annual estimates of one or more steelhead fishery parameters were available from BC provincial and regional fishery reports of field studies. Comparisons from the province-wide dataset show mean upward discrepancy for SHA estimates relative to field results of 42% for number of anglers, 58% for angler days, 83% for retained catch and 109% for released catch. However, most field studies in this dataset have yielded fishery parameter estimates subject to unquantified but substantial downward bias; the data provide a poor basis for assessment of bias in SHA parameter estimates. Dean River field studies from the period 1972-95 show mean upward discrepancy for SHA estimates of 28% for number of anglers, 27% for angler days, 63% for retained catch and 94% for released catch. A restricted dataset of Dean River studies from 1985-95 displays mean upward discrepancy for SHA estimates of 35% for number of anglers, 21% for angler days, 41% for retained catch and 75% for released catch. Although the Dean River data provide approximately unbiased fishery parameter estimates, the comparative dataset probably

provides a poor baseline for quantifying SHA bias. Dean River anglers and angler behavior are highly atypical relative to other BC steelhead anglers and fisheries, in terms of characteristics which are likely to affect both nonresponse and recall bias. Additionally, the range of values displayed by Dean River fishery parameters is narrow relative to BC steelhead fisheries as a group; extrapolation of SHA bias outside of this range would be weakly justified.

Suggestions are offered for improved understanding of the precision and bias of SHA parameter estimates. Complete analysis of the 1984 Thompson River dataset is recommended, along with recovery of raw data from the 1978/79 and 1982/83 follow-up contact studies. The latter data would allow exploration of the possible variation in non-response bias among fisheries and between residency groups. Following consultation with regional fisheries personnel regarding uses of SHA data and desired precision and accuracy, simulation should be used to explore scenarios for modification of the SHA procedure to improve accuracy, probably using initial and follow-up contact by mail and telephone. Precision, freedom from bias, and expense form a three-way tradeoff; reassessment of how the SHA can meet current needs would be desirable given the demonstrated weaknesses and potential misapplication of the current data.

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1. INTRODUCTION

Since 1967, the British Columbia Fisheries Branch has utilized an annual mail survey to document trends in steelhead sport fishery effort and catch. Known as the Steelhead Harvest Analysis (SHA), the survey provides the only consistent means for provincial fishery managers to monitor angling activity on the 400+ steelhead streams in British Columbia. Annual voluntary use surveys of anadromous sport fisheries, though not necessarily distributed by mail, have been widely applied in western North America beginning in Washington state in 1947, Oregon in 1952, and Idaho in 1962 (Hicks and Calvin 1964). In other regions, occasional surveys of this type have been used to survey fishery characteristics for all types of freshwater fisheries conducted in the jurisdiction (e.g. New York state; Brown 1991).

In British Columbia, following the end of each angling licence year on March 31, a random sample of the year's steelhead licencees receives a questionnaire requesting information on their steelhead angling activity and catch of the previous licence year. The proportion of licencees sampled varies according to residency. Questionnaires are sent to about half of BC-resident licencees, while all or nearly all out-of-province anglers are selected to ensure an adequate return. Typically, half of the recipients respond. Approximately three-quarters of the respondents have angled for steelhead during the previous licence year. The resulting data set comprises the recollected activity of roughly twenty-five percent of the year's licenced and active BC steelhead angler population. The sample is stratified by residency and computationally expanded, to provide SHA estimates of the total annual activity and success of all anglers for BC steelhead on all waters (Billings 1982).

Inquiry into the accuracy of SHA fishery parameter estimates intensified during the 1970s, when comparable information about British Columbia steelhead fishery parameters from field-based angling use studies began to accumulate. Several creel study report authors noted large discrepancies between analogous fishery parameter estimates (e.g. Hooton 1976). In the previously-mentioned US jurisdictions where extrapolation was made from a survey return rate of roughly 30%, accuracy of harvest estimates was known to suffer from angler nonresponse (Hicks and Calvin 1964). Accordingly, between 1977 and 1983 two distinct methods were applied in British Columbia to formally investigate the accuracy of SHA parameter estimates. The first approach involved broad comparison with creel survey results; the second, follow-up contact with survey non-respondents.

In 1977, 1978 and 1979 creel survey results from studies conducted during the middle 1970s were compiled and summarized with respect to analogous SHA estimates (Narver 1977; Narver 1978; Ford and Narver 1979). Parameters of interest were residency-pooled total annual harvested catch and total annual effort in angler days. Discrepancy between SHA and field results was typically expressed as a percentage of the SHA estimate. Based on data available through 1979 representing 37 fisheries, unweighted mean discrepancy in estimated annual harvested catch was -26.5% for all streams, and -32.1% for streams with angling effort greater than 400 angler days (Ford and Narver 1979). For the same dataset, unweighted mean discrepancy in estimated angling effort was -41.8% for all streams, and -36.3% for streams with angling effort greater than 400 angler days (Ford and Narver 1979). The general implication of these summaries was that SHA estimates were much greater than comparable field survey results, in agreement with early fishery-specific creel survey observations. However, significant doubts remained about downward bias of the field survey estimates, which thus might not provide a valid basis for assessing SHA accuracy.

The second mode of investigation pursued by the British Columbia Fisheries Branch was follow-up contact with survey nonrespondents. Additional mail-outs can reveal the extent of nonresponse bias, by quantifying how the angler population sampled in the first response group differed from those remaining (nonrespondents). Second mailings were made in 1978/79 and 1982/83 (Ford and Narver 1979; Billings 1983). The 1982/83 follow-up survey sampled residents of Vancouver Island only and included telephone contact after the secondary mailing, albeit to a very small sample of nonrespondents (n=52; Billings 1983).

In both years, results of follow-up contact were interpreted by comparing the SHA parameter estimates from the first mailing to those derived from the second mailing alone, as well as estimates obtained by combining the samples. For 1978/79, this interpretation of the results suggested that *"the estimate based on the first mailing was not significantly different from that based on the combined sample. The time and expense of a second mailing appears unwarranted"* (Ford and Narver 1979). In 1982/83, similar interpretation of the results of the follow-up contacts led to the conclusion that "*since the ratio of active and successful anglers remained relatively constant at all response levels, it might be safe to assume that catch estimates from the first mailing are reliable*" (Billings 1983).

Despite the latter conclusions, field-based angler surveys in the 1980s and 1990s have continued to suggest moderate to severe upward bias of SHA parameter estimates. In contrast to most early field-based studies, later surveys have either used statistically defensible designs or achieved near-complete coverage due to the operational details of the fishery, thus providing stronger evidence of bias in SHA estimates.

In the past, managers have treated SHA results as an indicator of general trends in steelhead fishery parameters, an application not necessarily requiring known precision and freedom from bias. However, growth in angling popularity has demanded more exact plans for management of use by steelhead angling sectors. If the SHA is to prove useful in the development and prosecution of management plans, rather than a detriment due to unknown bias and imprecision, an improved understanding of its statistical characteristics is needed. This document attempts to provide such a treatment of the survey, by answering the following questions:

1. What is the typical relationship between steelhead fishery parameters estimated by the SHA and those estimated by other studies of steelhead angling activity?
2. Does existing information allow assessment of the statistical properties, namely bias and precision, which define the accuracy of SHA estimates?
3. If so, what is the bias and precision? If not, what might be done to quantify these properties of the survey?
4. What does existing information suggest about sources of error in the SHA?

To approach the first three questions, British Columbia Ministry of Environment and Parks (BCE) field-based creel surveys of steelhead continue to provide the only available comparison to the SHA. For a few rivers, extensive series of annual studies now exist. Validation of the SHA has been a stated purpose of several field-based surveys, though not necessarily the sole objective. The present province-wide dataset is considerable larger than in 1979, when this type of comparison was last attempted.

Properties of SHA and field data may provide evidence of the causes of bias and imprecision in each, helping to answer the fourth question. In addition, an alternative approach to analysis of the 1978 and 1982 follow-up contact data is relevant. More recent methods for treating such data differ substantially from the approach which was taken at the time of their collection.

To set the stage for this document, the remainder of the introduction reviews the types of inaccuracies typically present in angling use studies of the types conducted in British Columbia. Angler survey errors have been grouped into three general categories: sampling, response and nonresponse errors (Essig and Holliday 1991). Sampling error refers to non-representativeness of the angler sample. Response error describes inaccuracy in the data stemming from angler mis-reporting. Nonresponse error occurs when survey nonrespondents differ systematically from those who do participate. Mail surveys such as the SHA are typically subject to certain types of errors within these three categories. Field surveys also tend to display certain biases, often different than those of mail surveys. Those which appear most applicable to the SHA and comparable field data are discussed briefly in the following sections.

1.1. Survey Error

1.1.1. Mail Surveys

1.1.1.1 Sampling Error

Of the recognized types of survey sampling error, undercoverage of the angling population is perhaps most likely to cause bias in the SHA. Because the sample selection is made from angling licencees, certain components of the angling population are not included in the sample frame. Among these are anglers under 16 years of age, status Indians, and others who fail to purchase a steelhead licence. Undercoverage would cause the SHA estimates of total activity and catch to be biased downwards.

1.1.1.2 Response Error

Survey response errors possibly influencing the SHA include recall bias, rounding bias, prestige bias, and intentional deception. Recall bias refers to memory failure, such that respondents experience difficulty recalling the details of their activity and success during the survey period (Pollock at al. 1994). If memory failure leads to angler responses which tend to be different more often in a particular direction, bias results. For instance, angler memory may be selective such that angling success is recalled moreso than angling failure. Alternatively, the magnitude of effort and/or catch during successful or unsuccessful angling experiences may be exaggerated in memory. Conventional wisdom suggests that angler memory is highly subjective and might tend to magnify the positive; the creel survey literature does not appear to provide evidence to confirm or deny this.

Rounding bias refers to the tendency for anglers to round their reported catch or effort numbers, often upwards. Rounding may occur to the nearest even digit or to a multiple of 5 or 7. This type of error could be expected to create a slight positive bias in SHA estimates.

Prestige bias refers to inflation of response by the angler to enhance their own image, creating a positive bias in resulting estimates (Pollock et al. 1994). No reliable method for differentiating between memory bias and prestige bias is apparent, but the latter seems less likely a widespread factor given the anonymity of the SHA.

Intentional deception could result from anglers concealing or exaggerating activity or catch, possibly to influence fishery management or for other reasons. Again, it is unclear whether this type of error would be likely to create bias in SHA estimates.

1.1.1.3 Nonresponse Error

Survey nonresponse error, including refusal to answer, is probably the most potentially serious shortcoming of mail surveys. Mail survey nonrespondents are often the less active or successful participants in a fishery (Brown 1991; Pollock et al. 1994). The result of failure to respond is that anglers with greater-than-average activity and/or success are over-represented in the respondent sample, leading to positive estimate bias. Available information suggests that BC steelhead angler success is dominated by a small proportion of the participants. This property of BC steelhead fisheries could be expected to cause particularly harsh estimate bias in the SHA if nonresponse error is as prevalent as for other mail surveys.

1.1.2. Field Surveys

British Columbia steelhead fisheries are often spatially and temporally diffuse. Early and late-season angling, as well as activity in less-accessible areas, can be very difficult to quantify. Many field-based steelhead creel studies are not intended only to quantify the absolute magnitude of effort and catch, but also to provide an enforcement presence and to collect biological samples from the catch. Because of these multiple objectives and limited staff resources, surveys have used a broad and eclectic mix of methods. As a result, categorization of survey design types is difficult and an organized description even more so.

Discussion of design and technique is presented in following sections. Design is considered to be the overarching framework for collection and, if needed, computational expansion of information. Technique is then the specific operational methods used to collect the required data. Field-based angler surveys are frequently subject to certain types of recognized biases, though often of unknown magnitude and direction. The biases discussed next are the ones most likely to be introduced by the field techniques commonly used to survey BC steelhead fisheries.

1.1.2.1 Sampling Error

Avidity bias refers to a survey situation whereby avid anglers (i.e. those that fish more often) are more likely to be sampled, during an access point or roving design survey. More frequent sampling of avid anglers does not necessarily induce bias in catch and effort estimates. Bias results only when avid-angler data is disproportionately represented.

Length-of-stay bias occurs in roving surveys, such that anglers who fish for more hours in a day have a higher probability of being sampled. If those anglers' success rate differs, then estimates of total catch will be biased. Length-of-stay bias is similar to avidity bias, but occurs on a daily rather than seasonal time scale.

1.1.2.2 Response Error

Prestige bias has already been discussed in the context of mail surveys. Prestige bias seems more likely to cause upward bias in on-site face-to-face interviews. Some anglers may not wish to admit an unsuccessful day of angling to the creel clerk.

Recall bias was also discussed in the context of mail surveys, and might be problematic in certain types of field-based surveys. If data are not collected from anglers at the end of each angling day, but at the end of the trip or after several days, recall may be slightly problematic.

1.1.2.3 Nonresponse Error

Biased estimates result when anglers refuse to return daily questionnaires or logbooks from field-based surveys, if the anglers who do not respond tend to differ in their effort or catch from those who do respond. As with mail surveys, field survey non-respondents typically are not a random sample with respect to effort and catch, thus causing upward bias when the responding sample is expanded to estimate total effort and catch.

1.2. Other Discrepancies Between Field and SHA Parameter Estimates

Field creel data and SHA estimates are not necessarily well-matched spatially or temporally. For instance, discontinuity in the name of the dominant river may cause variability in SHA responses by anglers on a number of river pairs. Examples are the Chilko & Chilcotin, Atnarko & Bella Coola, and Morice & Bulkley. Field creel surveys for the former two systems recognized the spatial continuity of their steelhead fisheries, but Morice & Bulkley data are more problematic.

As well, winter steelhead fisheries often span the March 31 licence year boundary. Angler confusion about reporting may result. It is usually difficult to separate reported field survey results into the appropriate licence years, and impossible to partition SHA results across licence years. Steelhead angling activity may vary greatly from year to year, so rough parity (between an angling season and the nearest-match licence year) cannot necessarily be assumed.

BC steelhead fisheries have occurred within a dynamic regulatory arena, particularly during the last decade. Changes in daily and seasonal retention quotas, tackle restrictions, angling guide regulation and classified waters legislation all have affected the participation and behavior of various sectors. Local resident steelhead anglers may have been less likely to have purchased a steelhead tag during the last decade for angling on non-classified waters, as some steelhead harvest opportunities were suspended for conservation reasons. Anglers who do not purchase a steelhead licence remain unsampled by the SHA procedure.

2. METHODS

2.1. Conventions

This document considers a steelhead fishery to constitute the steelhead angling activity on a particular named stream within a particular licence year. Angling licence years are often referenced by the second calendar year encompassed. For instance the 1996/97 licence year, which began 1-April-1996 and ended 31-March-1997, is referred to as 1997. This convention can create confusion, particularly since most summer steelhead fisheries no longer occur during the late winter and spring. Thus according to the convention, the 1997 Morice steelhead fishery occurred wholly within the 1996 calendar year, but did exploit 1997 spawners.

2.2. General Computational Techniques

Most data manipulations for this study were performed in MS Access®, using software-resident functions. Bootstrapping of standard errors was coded by the author as an MS Access® module, written in Visual BASIC®. Other statistical estimation was performed using the analysis software S-Plus® (Versions 3.3 and 4.5 for Windows). Confidence intervals were 0.95 and alphas were 0.05 unless otherwise stated.

2.3. Steelhead Harvest Analysis

2.3.1. Data Sources

A digital database (MS Access® platform) of fishery-specific SHA annual effort and catch estimates from 1968 to 1996 was provided by the Licencing and Administration Section, Victoria. Within the database, results from 1981/82 and earlier are not residency-stratified. Forward from 1982/83 inclusive, residency is categorized by BCE region (8 in total) for BC residents, and non-residents are classified as Canadians or non-Canadians, giving a total of ten residency categories. Within the years of residency-stratified data, in 1982/83 a small proportion of the data are residency-unknown, but all data after that licence year are fully categorized by residency.

Annual SHA reports for 1967/68 to 1994/95 (printed copy) available from Skeena Region files were scrutinized for comparable data, particularly pre-1982/83 residency-stratified results not present in the digital database. In some cases, filed printouts summarized results which were not presented in the annual report series --- for instance, effort (angler days) by residency was occasionally available from these sources, though not included in the annual report series.

Individual questionnaire responses, for the period 1983 to 1997 only, were also made available as a distinct digital database (roughly 145,400 records; MS Access®).

2.3.2. Characterizing Steelhead Fisheries

From 1967/68 to present, more than 400 British Columbia streams have been identified by SHA questionnaire returns as receiving steelhead angling effort on occasion. A detailed examination of the attributes of BC steelhead fisheries is beyond the scope of this report. However, the residency composition and typical activity of participants in some fisheries may influence SHA estimates differentially. For this reason, an overview of selected fishery characteristics is useful.

In order to characterize steelhead fisheries according to the effort parameters which are estimated by the SHA, annual means were estimated for all fisheries. Thirteen years' data (1984 to 1996) were included, that being the period for which all data were residency-specific. Fisheries were ranked in descending order by the total number of angler days estimated to have been expended during that period. The top 91 fisheries comprised 95% of the total estimated steelhead angling effort in BC, and were selected for further summary calculations.

2.3.2.1 Angler Residency

For each stream, angler residency was reclassified as local, BC, or non-resident. Local residents (coded L) were those who resided in the BCE region where the stream in question is located. The BC residency class (coded B) included anglers residing in all other regions of BC. Non-residents (coded N) were those anglers residing outside of BC, including non-Canadians. In addition to angler days, mean annual parameters stratified by residency type which were estimated for the popular fisheries included number of anglers, number of days fished per angler, and number of other streams fished in the same year.

Finally, streams were classified by the mean residency composition of the angler-days expended in the steelhead fishery during the time period 1984 to 1996. The residency composition code was created by appending, in order of magnitude, the code for each residency type which comprised more than 20% of the mean annual activity on the stream. For instance, for fishery type "L" only the local component comprised greater than 20% of the effort; for fishery type "NB" both BC residents and non-residents comprised more than 20%, with non-resident effort greater than BC resident effort.

2.3.2.2 Angler Activity and Catch

To characterize steelhead angler behavior, individual responses were pooled for the 91 most popular fisheries, 1984 to 1996. Considering each individual's annual reported activity and catch on one stream as a single observation, the resulting dataset totaled 134,683 observations. Frequency distributions for angler days, steelhead retained and steelhead released were tallied for the pooled dataset. Cumulative frequency distributions were plotted for the ordered tallies. The ordered tallies were also to generate cumulative proportion - proportion plots for the same parameters of activity, harvested and released catch. For instance, the proportion of anglers who angled *n* days or less per year, was plotted against the proportion of all angler days which such activity represented.

2.3.3. Precision of Estimated Parameters

Confidence intervals for SHA fishery parameter estimates were obtained by bootstrap. The bootstrap procedure is a Monte Carlo method which involves randomized re-sampling of the existing data (Sokal and Rohlf 1995). When a large number of re-sampling "runs" are made with the parameter of interest estimated from each run's result,

- the mean of the runs' parameter estimates should approximate the true parameter estimate from the data (this can be used to double check that the re-sampling algorithm is accurate);
- the standard deviation of the parameter estimated from run results should approach the true parameter estimate standard error, thus allowing construction of a confidence interval for the parameter estimate.

The bootstrap algorithm and confidence interval estimation routines are attached as Appendix I. For each estimate, 500 bootstrap runs were made. For each of the 10 residency groups defined by the Steelhead Harvest Analysis, confidence intervals were estimated as ± 2 standard deviations of the means of run estimates, for the parameters total angler days, number of anglers, and steelhead retained and released. Intervals were then summed to provide estimates for local, BC, and non-resident angler groups as defined previously.

Bootstrap estimates could only be made for fisheries for which individual SHA response data were available (e.g. post-1982 data). Intervals were generated for 34 post-1982 fisheries for which field surveys were recorded, to allow examination of whether field survey estimates typically fell within the confidence intervals of SHA parameter value estimates.

To create an additional exploratory dataset, SHA parameter confidence intervals were estimated for 7 Skeena Region streams for 1985, 1990 and 1995, constituting 21 fisheries in total. Intervals for 22 of the field study fisheries were also included in the exploratory dataset giving a total of 43 fisheries. Twelve of 15 Dean River years were excluded from the exploratory dataset to avoid over-influence of that stream's data on more general analyses.

Because bootstrapping is computationally expensive and potentially challenging to implement, it would be desirable to know whether the existing data could be used to develop simple but reasonably precise empirical formulae for generating confidence intervals. To examine the potential of this approach, standard errors were regressed on the associated estimates, after logarithmic transformation of both variables.

Finally, a set of 'rough-and-ready' rules for estimating SHA confidence intervals were obtained from the bootstrapped standard error estimates. For each fishery parameter, the quartiles of the parameter values were calculated. Within each quartile the median standard error, expressed as a percentage of the parameter value, was tabulated.

2.3.4. Follow-up Contact

On two documented occasions, follow-up mailings have been made to a portion of SHA non-respondents to assess non-response bias (Ford and Narver 1979; Billings 1983). On the second occasion, a telephone follow-up was made subsequent to the second mailing. Reported results (Ford and Narver 1979 Tables 2 and 3; Billings 1983 Table 8) are reproduced in Appendix II (Table A1 through Table A3).

Sample size for the telephone survey was very small. Angler response may differ depending on contact method, a factor which was not investigated. For these reasons, the telephone results are not given further quantitative consideration in this document.

Tabular results of the follow-up mailings were examined for their utility for re-summarization. The 1978/79 data contain apparent discrepancies which are difficult to explain, particularly in light of the minimal reported methodological detail. Most of the discrepancies occur in the "combined results" or "1st and 2nd" columns. These columns were thus excluded from analyses, and the equivalent combined results obtained by recalculation from the distinct results of the first and second mailings.

Analyses of the initial and follow-up mailing results was made using the method of Filion (1975, 1976) as referenced and applied in Hooton (1985). A conceptual representation of the method is given in Figure 1. In the case of only two mailings linear regression is unnecessary and the final estimate can be obtained by simple geometry. The final parameter estimate is then obtained by multiplying the extrapolated final "parameter per response" value by the number of licencees. In this document, apparent bias is just the ratio of the initial estimate to the final estimate.

Apparent bias might be expected to be correlated with high variance in angler behaviour, since variability in effort and catch is believed to be one component of the non-response bias problem. Individual angler response data were not available for the 1978/79 harvest analysis. Coefficients of variation for angler days and retained and released catch were estimated from the pooled 1983-1995 data for each river, as a surrogate.

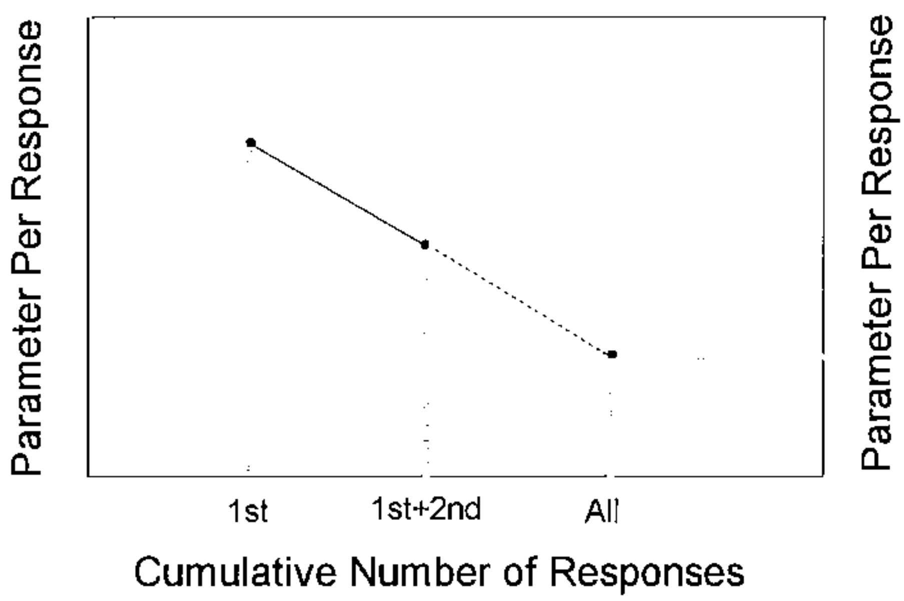

Figure 1.—Conceptual representation of the method of Filion (1975) for analysis of multiple-contact survey results. With only two mailings, the computations are simple geometry.

2.4. Field Surveys

2.4.1. Data Sources

Five BC Environment (BCE) administrative regions manage fisheries for winter or summer steelhead, or both. Staff in each BCE region collected and forwarded photocopies of reports of field-based steelhead creel studies from regional libraries or files. Reports were examined for catch and effort estimates, and other relevant methodological detail, as described in section 2.4.2 below.

Review of the annual SHA report series yielded field creel survey results which were not represented in reports received from the BCE regions. Specifically, Narver (1977; unnumbered table), Narver (1978; unnumbered table) and Ford and Narver (1979; Table 1) provided residency-pooled effort and harvest data for about a dozen additional creel studies in various BCE regions. No additional information about operational detail or techniques was compiled for these studies.

2.4.2. Survey Designs, Techniques and Biases

Field study procedures as recorded in the survey reports were examined to tabulate study designs, and to code and tabulate techniques and additional biases for each survey. Techniques commonly applied are listed in Table 2. Biases (Table 1) typically associated with each technique are also given. Study methods are often under-documented or unclear in presentation in the available reports, particularly computational procedures. Assessment of whether full spatial and temporal coverage were achieved was often not possible.

Table 1.—Types of error created by angler survey techniques used for BC steelhead fisheries. The column **Code** gives a one-letter code used in other report tables to denote the bias.

Bias	Code	Notes
Avidity	**A**	Avid anglers are more likely to be sampled because of the number of days spent angling
Length of stay	**L**	Angler probability of being sampled is proportional to length of time fished on a day
Memory	**M**	Angler memory (> 1 day) is a significant factor
Nonresponse	**N**	Anglers have the opportunity to avoid contributing to the sample
Spatially unrepresentative	**S**	Spatial portion of the fishery under-sampled
Temporally unrepresentative	**T**	Temporal portion of the fishery under-sampled
Design	**D**	Survey design likely to create bias for reasons other than the above factors

Table 2.—Techniques used for field-based creel surveys of BC steelhead fisheries. The column headed **Code** gives the code for the technique, used in other tables in this document. The column headed **Biases** gives the bias code (Table 1) for any biases which are often associated with the technique. Techniques are not necessarily independent or exclusive; for instance, individual tracking subsumes cumulative detail, etc.

Technique	Code	Biases	Notes
Instantaneous count	**C**	L	Includes angler and vehicle counts or both; may be aerial or surface
Roving interview	**R**	L	May include road access points, boat launch sites, or on-river interviews of anglers for effort/catch data
Access point	**A**	-	Interviews, only conducted at end-of-trip when angler returns to access point
Cumulative detail	**Z**	A, L, M	Tallying of participant catch and effort since last check, without tracking individuals
Individual tracking	**I**	A, L, M	Tallying of participant catch and effort since last checked; may include name lists or numbering of angler licences
Voluntary questionnaire	**V**	A	Daily; often distributed by roving clerk
Logbook	**L**	A, N	Daily totals, maintained for entire season
Guide/lodge records	**G**	M, N	Angling guide reports or other records
Exit checkpoint	**X**	N	Used when road exit is by a single point
Full coverage	**F**	D	Attempt to record all effort and catch
Random sampling	**B**	-	Subsampling in units of time (whole day or less than a day), not stratified
Spatial stratification	**S**	-	Spatially stratified random sampling
Temporal stratification	**T**	-	Temporally stratified random sampling, such as weekday / weekend, AM / PM, or early season / late season
Unknown expansion	**E**	D	Survey notes extrapolation or interpolation but does not give operational detail

2.4.3. River Pairs

Several field studies present combined data for two streams. For most parameters of interest (angler-days, catch retained and released) a comparable SHA estimate can be obtained by summing the estimates for the two rivers. However, the number of individual anglers cannot be estimated in this way, because typically there are individuals who have fished both rivers. Summing the SHA estimates of number of individuals who angled each river would thus over-estimate the total number of anglers active on the river-pair. In such cases (primarily the Chilko & Chilcotin), no method was available to adjust for this factor prior to 1983, so this parameter was excluded from further comparison. The digital database of individual responses was used to estimate and adjust for the number of individuals who angled both streams for post-1983 studies.

2.4.4. Results Traverse Licence Years

The Atnarko and Bella Coola fisheries of 1976/77 and 1977/78 occurred in both fall and spring within each licence year. Results from studies in each of these years did not cover the entire licence year, but were presented as monthly totals which could be recombined to represent the single complete licence year of 1977/78. An angler use study on Gold River (Vancouver Island) in 1975 and 1976 also spanned two licence years, neither of which received full coverage due to the fall-and-spring nature of the fishery. Accordingly, the study was excluded from analyses.

2.4.5. Residency

Angler residency has been categorized by a variety of schema during field-based creel studies of BC steelhead fisheries. In a few cases, residency was recorded exactly as represented by SHA returns. Most often however, the local resident component was defined by residency criteria different than those used by the SHA; for instance, local residents might be considered as those residing within 100 km of the river or in certain nearby towns, rather than those residing in the same MOE region which contains the river. Each such case was evaluated with respect to whether the field estimates could be made reasonably comparable to SHA results, by recalculation if necessary.

2.5. Relating Field Estimates to SHA Estimates

2.5.1. Expected Relationships

This document does not report tests of specific hypotheses about the relationship between SHA and field creel study fishery parameter estimates. However, an expectation of the possible form of such relationships is necessary as a foundation for any quantitative descriptions. Considering the field data as the independent variable (representing the best available estimates of the true fishery parameters), a parsimonious expectation is that the matching SHA estimates are a linear function of the field data. The linear relationship should have slope greater then one and y intercept greater than zero. A non-zero intercept is expected because anglers cannot report negative values, and on average some reporting of activity which did not occur is anticipated. Slope greater than one is expected if SHA parameter values differ from the comparable field estimate by an absolute amount which increases with the magnitude of the field parameter value. Admittedly there is no *a priori* reason for these relationships to be linear, in other words displaying a constant proportional difference neglecting the intercept. Linearity is offered as a parsimonious model, in the absence of information to the contrary.

2.5.2. Quantifying the Relationships

For each fishery parameter, four comparison datasets were compiled: a global dataset of all appropriate values unstratified by residency, a second global dataset of residency-stratified data, and two Dean River datasets of residency-unstratified data. The distinct Dean River datasets were created as a result of the temporally extensive data series for the river, as well as the expectation that the Dean creel surveys are relatively accurate due to the logistics of the fishery. The first Dean dataset contained all available data between 1972 and 1995. The 'restricted' Dean dataset included only data for the years 1984 to 1995, when poorly quantified activity (by sectors such as loggers working in the watershed) had become minimal.

Conventional least squares methods were applied to the various comparison datasets to estimate linear regression coefficients. In addition, robust regression by the "least trimmed squares" approach (Statistical Sciences 1995) was used to explore the sensitivity of the regression coefficients to outliers.

Non-linearity over the available range of parameter values was also considered possible, due to either small sample size and high variance, or a different underlying relationship. As an alternative to the regression approach, for each fishery parameter dataset with sufficient sample size, data were separated into quartiles based on the SHA parameter values. For each data pair, the ratio of the field estimate to the SHA estimate was calculated and for each quartile, the median ratio was tabulated.

3. Results

3.1. Steelhead Harvest Analysis

3.1.1. Characterization of BC Steelhead Fisheries and Anglers

Selected characteristics of popular BC steelhead fisheries are summarized in Table A4 (Appendix III), which presents annual mean values stratified by residency class and arranged by region. Vancouver Island Region supports the highest number of listed fisheries with 37, followed by Skeena Region with 27 (Table 3). A substantial majority of popular fisheries were dominated by local anglers during 1984 to 1996. Of the 91 streams examined, 75 were categorized as type "L" during the period (Table 3). In other words, for only 16 streams did the BC-resident or non-resident sectors, or both independently, contribute more than 20% of estimated angling effort (Table 3).

Table 3.—Categorization of popular BC steelhead fisheries, by BCE region and residency composition of effort. Residency composition types are described on page 8.

Region	Residency Composition									Total
	L	LB	LN	LBN	LNB	BL	NB	NL	NBL	
1	36	1	0	0	0	0	0	0	0	**37**
2	20	1	0	0	0	0	0	0	0	**21**
3	0	0	0	0	0	1	0	0	0	**1**
5	1	2	0	0	0	0	2	0	0	**5**
6	18	1	1	2	1	1	1	1	1	**27**
Total	75	5	1	2	1	2	3	1	1	**91**

Components of steelhead angler behavior, as characterized by SHA responses and stratified by residency class, are presented in Table 4 through Table 7. These tables provide descriptions of two types of distributions:

(1) the pooled distribution of responses from *individual anglers* (n = 78,584) who participated in at least one of the most popular BC fisheries as defined previously, and

(2) distributions of *fishery means* (n = 91), which are reported by fishery in Table A4.

The distinction between the two types of distributions and statistics must be emphasized, because the summary statistics are not necessarily comparable.

Residency-stratified angling effort and success are presented in Table 4 and Table 5. On average, local anglers reported expending more effort, in units of angler-days per stream per year, than either non-local BC anglers or non-resident anglers (Table 4; Table 5). Non-resident anglers reported spending a slightly higher number of days per stream angled per year than non-local BC residents. Local anglers also reported harvesting more fish, with non-resident anglers displaying the lowest annual harvest per angler. Non-residents reported releasing the highest number of fish per year per stream angled.

Ratios of variance to mean are much greater than 1, for distributions of both activity and success for all residency classes (Table 4). The implication is that the distributions of reported angler activity and success are clumped or over-dispersed. Reported steelhead angling activity is numerically dominated by anglers who expend relatively little effort per stream per year, and a second group of very avid anglers who expend much more effort per stream per year. This pattern is also true for angler success, and is re-emphasized by the displacement of the medians from the means of these distributions. Despite per-angler mean values of several fish released per stream per year, the median catch (killed or released) for all residencies is either 0 or 1. In other words, steelhead anglers are typically unsuccessful although a minority of anglers are very successful. There are less anglers whose reported behavior is intermediate, than would be expected based on the simplest possible theoretical statistical description of the distributions.

Cumulative frequency distributions (Figure 2 to Figure 4) graphically reinforce the evidence about differences within and between residency groups, in terms of angler behaviour. Cumulative-cumulative plots translate the patterns into their net impact on fishery annual total angling effort and catch (Figure 5 through Figure 7). For all residency classes, the reported effort and catch are concentrated within a relatively minor proportion of the participants. Among residency groups, for all parameters, the concentration is most exaggerated for locals.

Table 4.—Characteristics of per-stream angling effort and success by individuals of 3 residency classes. Estimated from a pooled dataset of individual SHA responses for the most popular 91 steelhead fisheries in BC, which comprised 95 % of steelhead effort in the province during 1984 - 96. **Days** gives the number of angler days reported for a licence year; **Retained** gives the number of steelhead reported harvested during a licence year; **Released** gives the number of steelhead reported angled and released alive. **Residency** is categorized as L = Local, B = BC non-local, and N = non-resident of BC. **Max** = maximum reported; **SD** = standard deviation, **S** = variance.

Parameter	Residency	Mean	Max	Count	SD	S	Median
Days	B	3.9	180	25767	5.1	26.1	3
	L	7.3	300	85836	11.0	121.4	4
	N	5.0	186	23073	4.8	22.8	4
Retained	B	0.55	61	25768	2.1	4.4	0
	L	0.94	850	85827	5.7	32.2	0
	N	0.43	80	23073	1.5	2.4	0
Released	B	2.4	207	25769	6.4	41.2	0
	L	3.3	866	85828	10.7	115.3	0
	N	4.4	161	23072	7.6	58.4	1

Table 5.—Characteristics of distributions of number of days per year per stream angled by individuals of 3 residency classes. Drawn from the fishery means, for the most popular 91 steelhead fisheries in BC, which comprise 95 % of steelhead effort in the province, 1984 - 96.

Parameter	Local (L)	BC Non-local (B)	Non-resident (N)
Mean	5.3	3.0	3.1
Standard Error	0.23	0.13	0.15
Median	4.7	2.7	2.8
Standard Deviation	2.20	1.19	1.38
Variance	4.83	1.41	1.91
Minimum	1.7	1.0	1.0
Maximum	12.4	6.6	7.0
Count	90	89	85

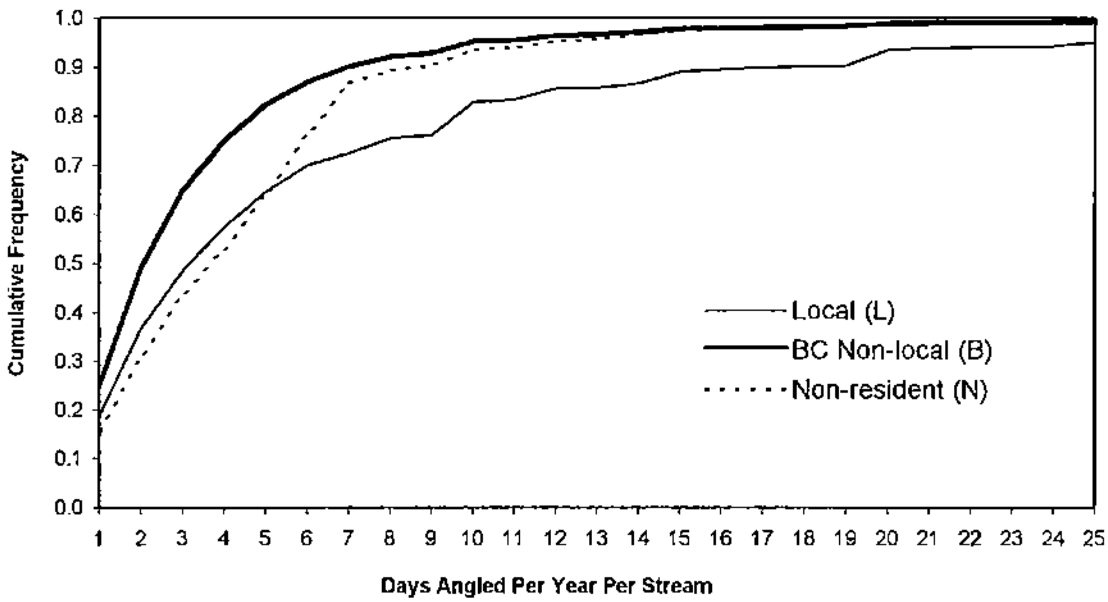

Figure 2.—Cumulative frequency distribution, of reported days angled per year per individual angler per stream, for three angler residency classes. Drawn from SHA reports for the 91 most popular fisheries in BC, 1984 to 1996.

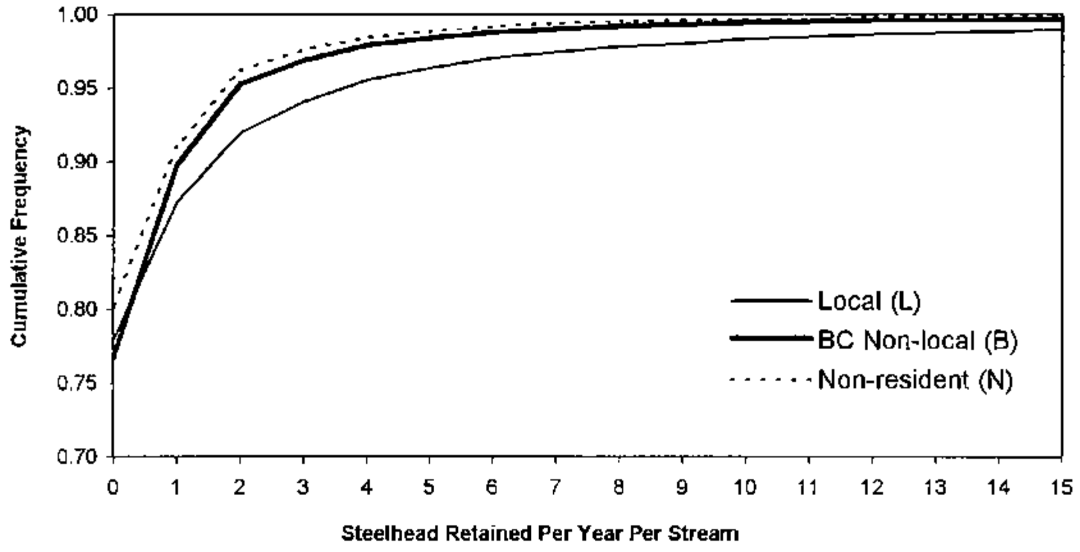

Figure 3.—Cumulative frequency distribution, of reported steelhead retained per year per individual angler per stream, for three angler residency classes. Drawn from SHA reports for the 91 most popular fisheries in BC, 1984 to 1996.

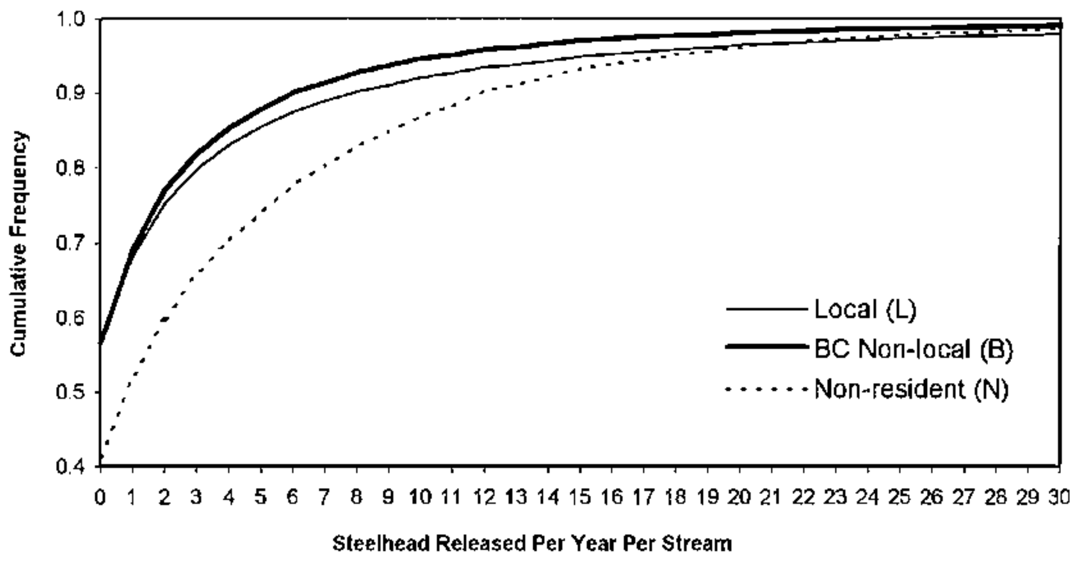

Figure 4.—Cumulative frequency distribution of reported steelhead released per year per individual angler per stream, for three angler residency classes. Drawn from SHA reports for the 91 most popular fisheries in BC, 1984 to 1996.

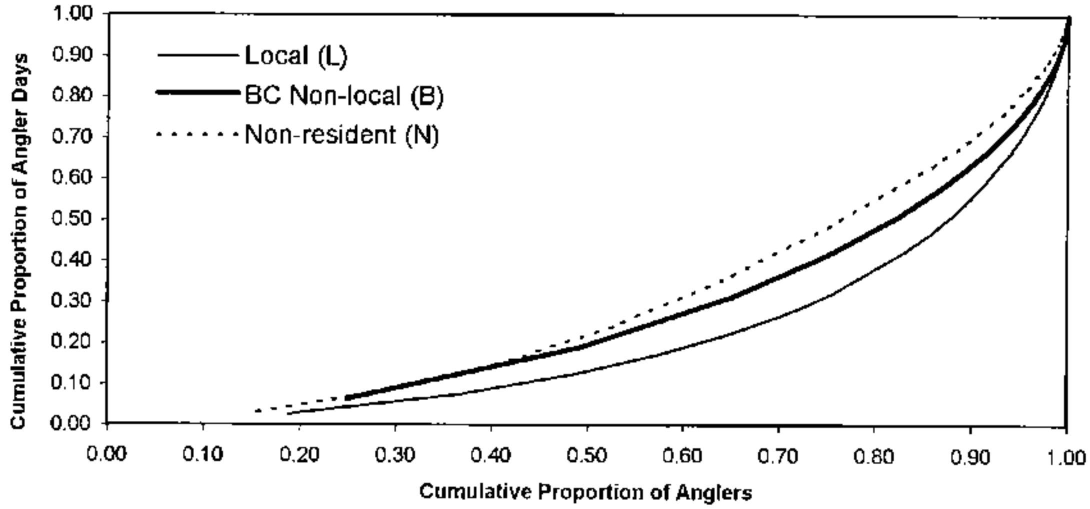

Figure 5.—Cumulative proportion of reported days angled, versus the cumulative proportion of anglers who participated, for three angler residency classes. Drawn from SHA reports for the 91 most popular fisheries in BC, 1984 to 1996.

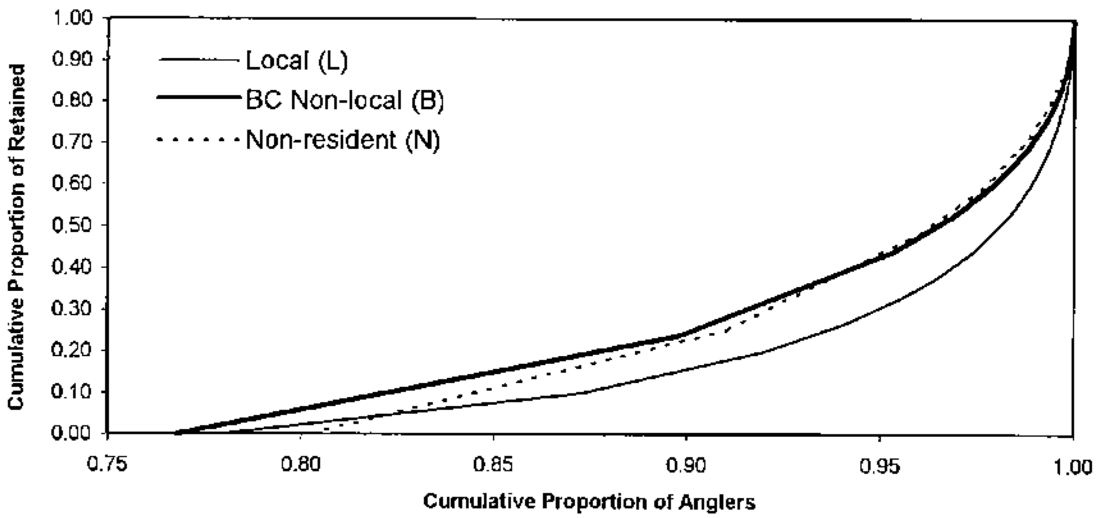

Figure 6.—Cumulative proportion of steelhead retained, versus the cumulative proportion of anglers who retained steelhead, for three angler residency classes. Drawn from SHA reports for the 91 most popular fisheries in BC, 1984 to 1996.

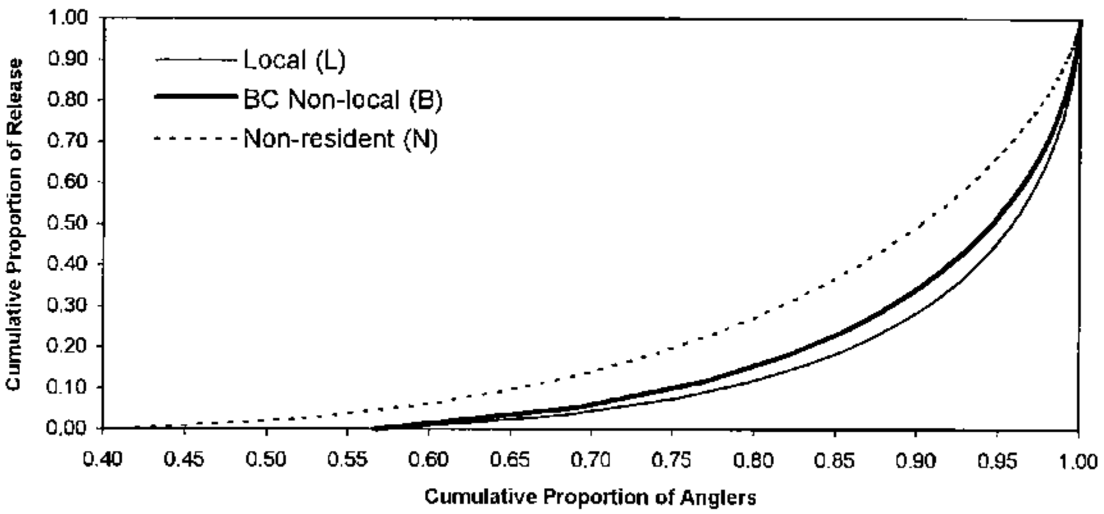

Figure 7.—Cumulative proportion of steelhead released, versus the cumulative proportion of anglers who released steelhead, for three angler residency classes. Drawn from SHA reports for the 91 most popular fisheries in BC, 1984 to 1996.

Characteristics of distributions of number of streams angled per SHA respondent are presented in Table 6 and Table 7. The distribution of fishery means (Table 7) provides a description of this component of angler behaviour which is very different than the parameters describing the pooled distribution (Table 6). Anglers who fish a large number of streams per year have a disproportionate effect on the mean of fishery means, because the influence of their high activity appears within the calculation for each of the streams angled. The parameters describing the distribution of fishery means function best as a baseline against which the typicality of the means for individual fisheries (Table A4) can be judged.

Of the angler residency types, non-resident and BC non-local anglers similarly tend to fish the lowest number of BC steelhead streams per year (Table 6). BC resident anglers who fish only waters within their region of residency --- e.g., locals --- tend to fish a greater number of streams per year. However, anglers in the "mixed" category --- e.g., anglers who fish waters both within and outside their region of residency --- display the highest number of streams angled per year, both within their region of residency and outside (Table 6).

Table 6.—Characteristics of distributions of the annual number of BC steelhead waters angled by individuals of four **Angler Types**. **Local** anglers are BC residents who fished for steelhead only in streams in their region of residence; **BC Non-local** anglers are BC residents who fished for steelhead only on waters outside of their region of residence; **Mixed** anglers are BC residents who fished for steelhead on waters in and outside their region of residence; **Non-resident** anglers resided outside of BC. The column # **of Local Streams Angled** gives the number of waters reported angled within the angler's region of residence; # **of Other BC Streams Angled** gives the number of waters reported angled outside the angler's region of residence. **Max** = maximum number reported, **S** = variance of the distribution. The dataset includes all (n = 78,584) individual SHA responses from anglers active in the most popular 91 steelhead fisheries in BC during the period 1984 - 96.

		# of Local Streams Angled			# of Other BC Streams Angled		
Angler Type	**N**	**Mean**	**Max**	**S**	**Mean**	**Max**	**S**
Local (L)	11,648	1.75	20	1.61	NA	NA	NA
BC Non-local (B)	43,709	NA	NA	NA	1.37	14	0.74
Mixed	6,498	2.24	17	3.17	1.69	16	1.59
Non-resident (N)	16,729	NA	NA	NA	1.43	23	0.92

Table 7.—Characteristics of distributions of annual number of BC steelhead waters angled by individuals of 3 residency classes. Drawn from the *fishery means* for the most popular 91 steelhead fisheries in BC, which comprised 95 % of steelhead effort in BC during 1984 - 96.

Parameter	Local (L)	BC Non-local (B)	Non-resident (N)
Mean	3.68	4.04	3.21
Standard Error	0.11	0.15	0.14
Median	3.74	4.21	3.00
Standard Deviation	1.06	1.44	1.31
Variance	1.13	2.06	1.71
Minimum	1.29	1.43	1.18
Maximum	5.89	7.86	7.17
Count	90	90	85

3.1.2. Rounding in Angler Reporting

Evidence about the tendency for anglers to round their reported activity is provided graphically in Figure 8. Multiples of 2, 5, 7 and 10 all show some evidence of over-representation, implying that anglers do round their reported activity. For instance, the mean ratio of categories which are multiples of 2 to the average of their lower and upper neighbors is 5.8. Similarly, the mean ratio of categories which are multiples of 5 to the average of their 4 nearest neighbors is 10.7.

However, the true distribution is unknown, and not necessarily typical of any theoretical distribution to which the reports might be compared. For instance, anglers may be more likely to plan trips for certain multiples of days. In addition, no conclusions are possible about whether upward or downward rounding is prevalent, which would determine whether bias would result.

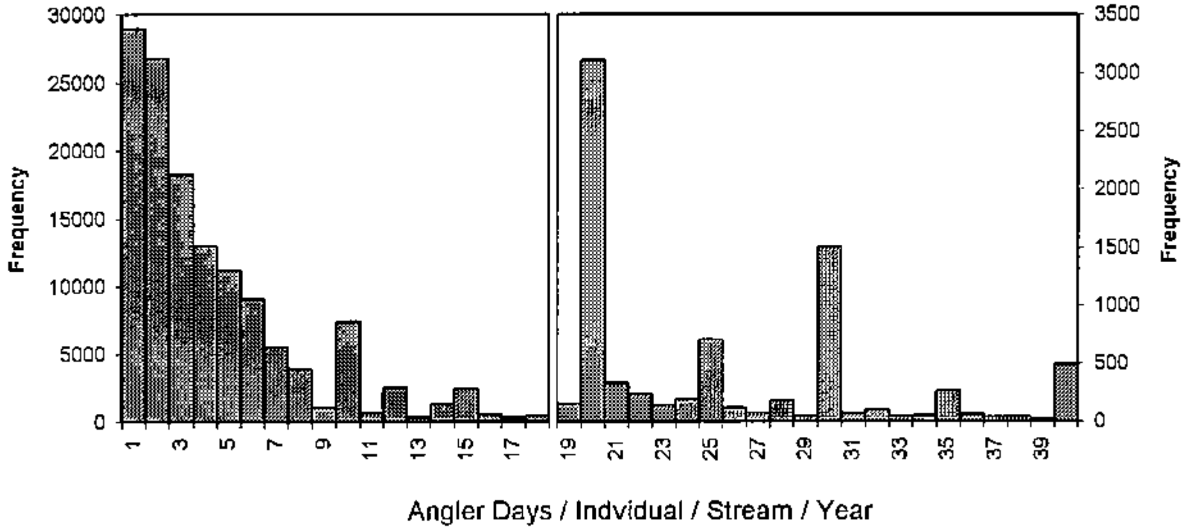

Figure 8.—Frequency distribution of reported days angled per stream per licence year. SHA, 1983 to 1996. All residencies pooled. Reported per-stream activity of greater than 40 days is not included. *Note Y-axis scale change midway along X-axis.*

<u>3.1.3. Precision of Estimated Parameters</u>

3.1.3.1 Exploratory Dataset

Bootstrapped standard errors for the exploratory dataset of 43 fisheries are provided in Table A13 (Appendix VII). The values display the relative imprecision of SHA estimates, as well as the variability in imprecision between fisheries. Figure 9a and 9b depict the relationship between estimates and their standard errors. The data are log-log transformed, with the transformations moderately effective in linearizing the relationships. Precision varies substantially among fisheries, at any given parameter level.

Precision also varies substantially among the residency classes (Table 8; Figure 9). Improved precision for non-resident anglers stems from the higher sampling (mail-out) proportion applied to that component of the angler population. For all four parameters of interest, relationships between logged fishery parameter estimates and logged bootstrapped standard errors are roughly linear. Distinction of whether these relationships differ in a statistically or functionally important manner is not offered; the SHA estimates used to derive the regression coefficients were chosen arbitrarily as was the sample size (number of fisheries). Should this type of empirical approach be applied in a broader context, a larger sample of fisheries and more thorough analysis of patterns would be required.

Table 8.—Log-log linear regression of bootstrapped standard errors on the associated fishery parameter estimates. Fishery parameters are annual totals, stratified by the residency classes shown; **b** = slope, **a** = intercept; **SE( )** indicates standard error of the regression coefficients.

Parameter	Residency	b	SE(b)	a	SE(a)
Anglers	BC (B)	0.462	0.012	0.438	0.022
	Local (L)	0.364	0.016	0.593	0.035
	NR (N)	0.422	0.011	0.334	0.019
	Pooled	**0.413**	**0.01**	**0.517**	**0.030**
Angler Days	BC (B)	0.637	0.021	0.419	0.052
	Local (L)	0.657	0.019	0.430	0.053
	NR (N)	0.620	0.016	0.344	0.036
	Pooled	**0.634**	**0.018**	**0.433**	**0.055**
Retained	BC (B)	0.546	0.027	0.449	0.050
	Local (L)	0.588	0.019	0.394	0.039
	NR (N)	0.571	0.036	0.359	0.057
	Pooled	**0.564**	**0.017**	**0.429**	**0.038**
Released	BC (B)	0.695	0.026	0.457	0.061
	Local (L)	0.716	0.026	0.389	0.065
	NR (N)	0.662	0.019	0.368	0.044
	Pooled	**0.670**	**0.021**	**0.470**	**0.059**

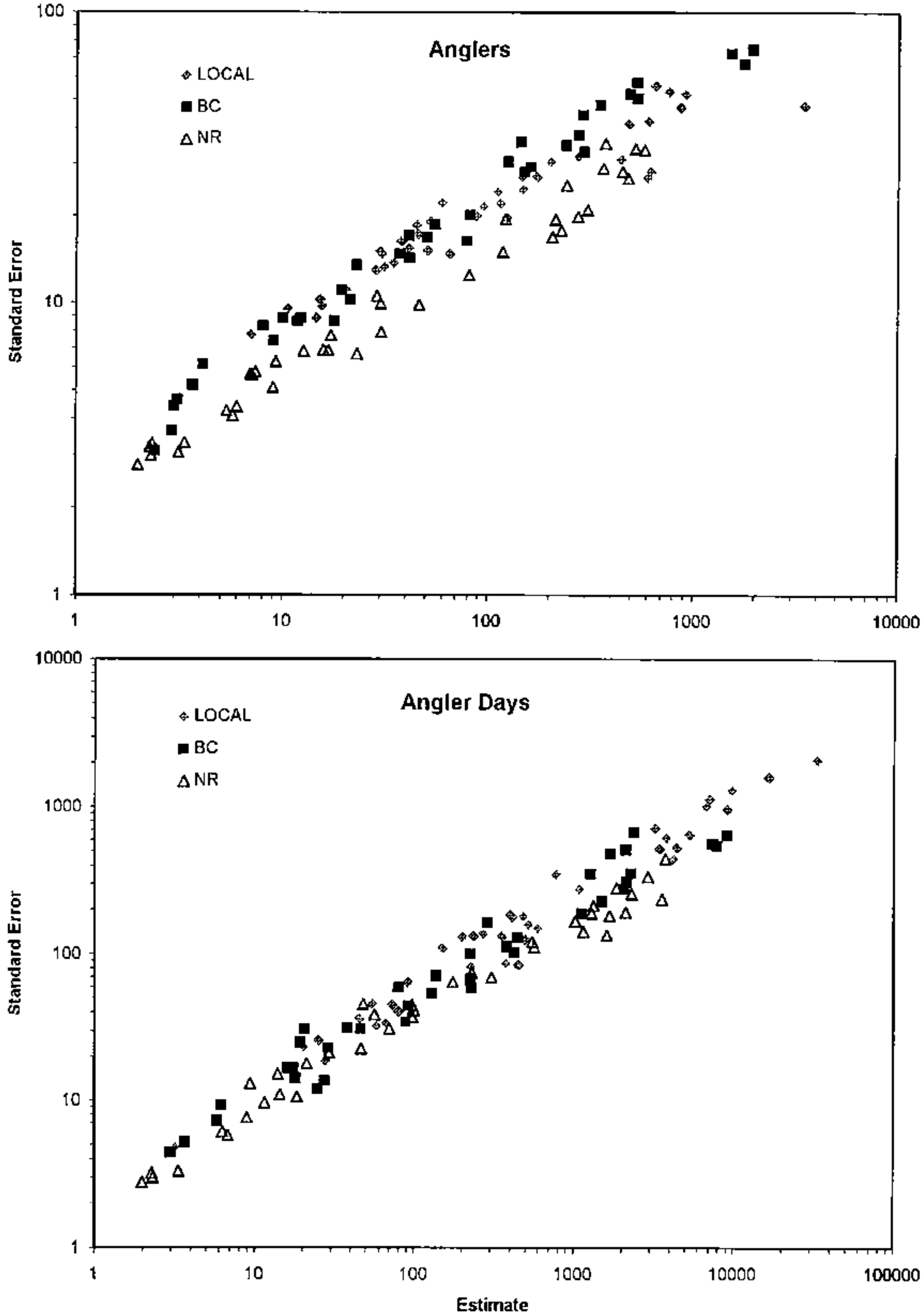

Figure 9a.—Log-log relation of annual SHA estimates to their bootstrapped standard errors, anglers and angler days, by residency. Additional explanation is given in the text.

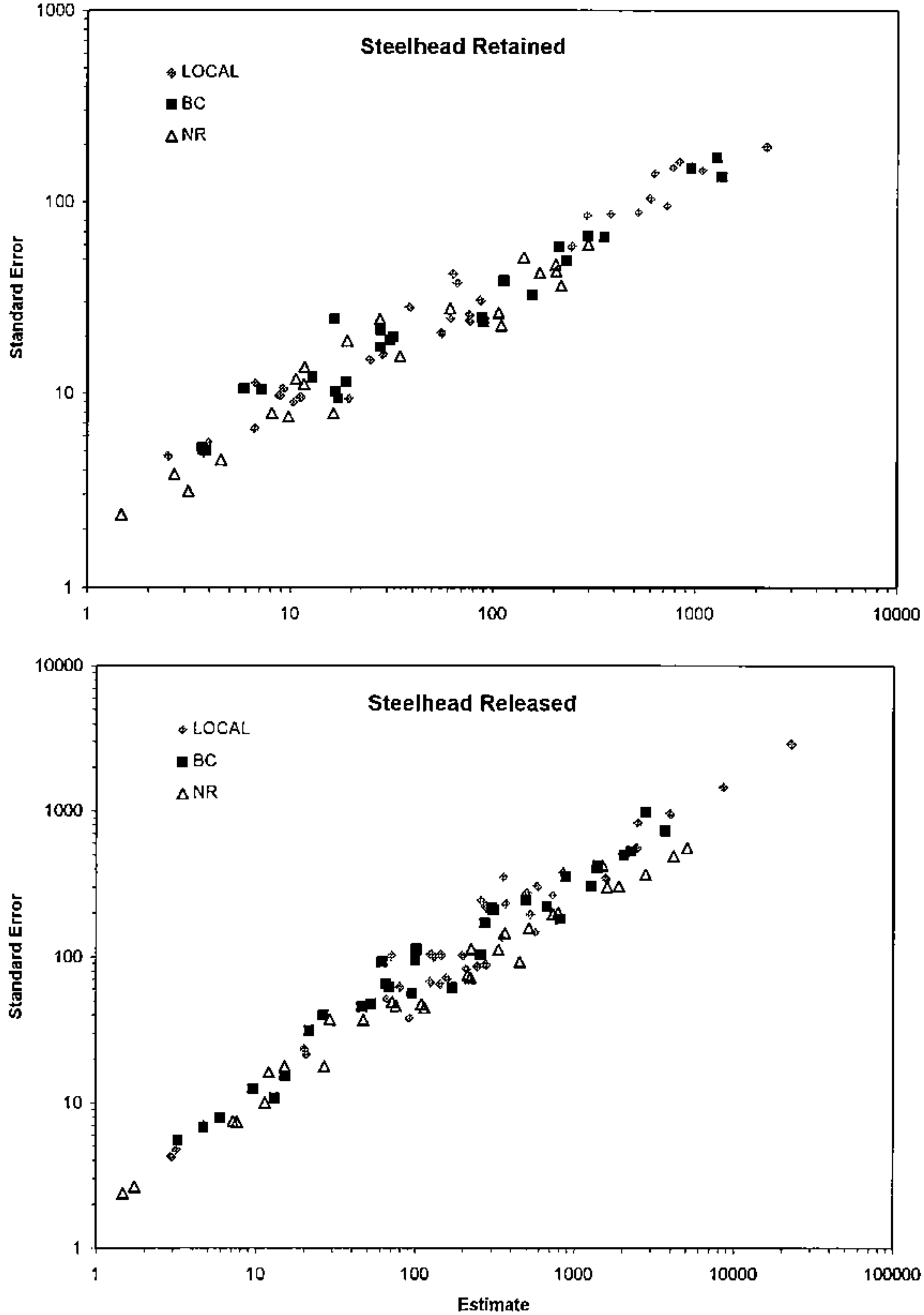

Figure 9b.—Log-log relation of annual SHA estimates to their bootstrapped standard errors, catch retained and released, by residency. Additional explanation is given in the text.

Typical percent-wise standard errors of SHA fishery parameter estimates unstratified by residency are provided in Table 9. To apply this table, simply find the parameter of interest, select the value range which contains the desired estimate value, and read the percentage from the final column. For instance, for the Zymoetz River in 1990, the SHA estimate of 426 anglers results in a percent-wise standard error from Table 9 of 9% and thus an absolute standard error of 38. The 95% confidence interval would then be 426 ± 77, or 349 to 503 anglers. Note that in this case, the approximate method under-estimates the bootstrapped standard error of 48 for the 1990 Zymoetz fishery (Table A13). As noted previously, at a given parameter value there remains large variability between fisheries in the apparent precision of estimates, which renders this approach as very approximate. An alternate approach would use the log-log regression equations (Table 8) to estimate the standard error for each residency class, for the parameter of interest. Re-transformation and summing of confidence intervals would give the all-residency confidence interval. Both methods are only empirical approximations drawn from the bootstrap results, which in turn were generated from a very small proportion of SHA data collected to date. In all cases, the best estimate of a confidence interval for the parameter estimate would be provided by applying the bootstrap procedure to the raw data.

Although only an approximate summary, Table 9 provides a basis for expectation about the magnitude of standard errors and thus confidence intervals for SHA results. First, estimates of retained and released steelhead catch are typically subject to much higher relative imprecision at all levels than are the corresponding estimates of effort. Second, in terms of activity, only the upper two quartiles display typical confidence interval widths less than the parameter values themselves, in other words percent-wise standard errors less than 25%. Almost all of the fisheries used to derive the Table 9 standards were drawn from the uppermost quartile, in terms of activity, of the 400+ steelhead fisheries in BC. The typical width of confidence intervals for SHA fishery parameter estimates for the remaining fisheries will thus be similar to those for the lowest value range for each parameter in Table 9. This implies typical confidence interval width of two or more times the parameter value.

Table 9.—Rough 'rule-of-thumb' standards for estimating standard errors of SHA parameters for a given value. Methods explained in the text. Approximate confidence intervals are calculated as the value of the estimate ± z standard errors, where z is the value of the z distribution at df = ∞.

Parameter	Quartile	Value Range	Standard Error (expressed as %)
Anglers	1	6 - 40	46
	2	41 - 162	30
	3	163 - 970	9
	4	971 - 3666	4
Angler Days	1	6 - 122	52
	2	123 - 599	39
	3	600 - 6696	15
	4	6697 - 33485	9
Steelhead Retained	1	3 - 15	108
	2	16 - 78	58
	3	79 - 768	20
	4	769 - 2292	12
Steelhead Released	1	3 - 124	73
	2	125 - 570	62
	3	571 - 3216	22
	4	3217 - 23262	16

3.1.4. Follow-up Contact

3.1.4.1 Aggregate Estimates

Estimates from re-analysis of the province-wide secondary mailing in 1978/79, and Vancouver Island (Region 1) follow-up contact in 1982/83, are presented in Table 10. These aggregate (provincial or regional) totals are essentially weighted means not corresponding directly to other fishery parameter estimates presented in this report, which are usually water-specific or unweighted mean parameter estimates. Nevertheless, all aggregate results suggest that SHA estimates made from a single mailing and the typical response rate are substantially higher than would be obtained from a complete (100%) response to the same mailing. Expressed as a percent of the final estimate, initial mailing estimates appear biased upward due to nonresponse by 24 to 29% for two of the parameters usually examined (number of active anglers and retained catch; Table 10). The number of successful anglers may be overestimated by 33 to 59% due to nonresponse.

Table 10.—Comparison of single-mailing SHA fishery parameter estimates to multiple-mailing estimates, 1978/78 provincial total and 1982/83 Region 1. The column headed **Initial** gives the estimate obtained from the results of the Initial mailing; **Final** gives the estimate obtained from all mailings by the method of Filion; **Bias** is **Initial** ÷ **Final**. Data are from Ford and Narver (1979) and Billings (1983).

	1978/79 British Columbia			**1982/83 Vancouver Island**		
Parameter	**Initial**	**Final**	**Bias**	**Initial**	**Final**	**Bias**
Anglers	15,788	12,694	**1.24**	2,887	2,331	**1.24**
Successful Anglers	6,746	4,241	**1.59**	1,856	1,390	**1.33**
Total Retained	14,700	11,422	**1.29**	N/A	N/A	**N/A**

3.1.4.2 Water-Specific Estimates

Table 11 and Table 12 present re-analysis of water-specific results of the provincial follow-up mailing in 1978/79. Ford and Narver (1979) provide data for only 14 waters, the majority of which lie on Vancouver Island or in the lower mainland. As with the aggregate parameters, the water-specific results suggest that SHA estimates made from a single mailing accompanied by the prevailing response rate are typically substantially higher than would be obtained from a full response to the same mailing. Expressed as a percentage of the final estimate, initial mailing estimates appear biased upward on average by 17 to 38%, depending on the measure of central tendency applied (Table 11).

Although the typical apparent bias of initial results is in the order of 20 to 30%, the results display considerable variability as evidenced by the range (Table 11) and scatter (Table 12, Figure 11) of the estimates. Of 56 initial estimates (4 parameters for 14 waters), 13 were lower than the re-estimated results. Variability in apparent bias is particularly high for the catch parameters, as might be expected given the high variability in reported catch from angler responses to the questionnaire. Relationships between initial and final estimates for the four parameters are depicted graphically in Figure 10, with standard least-squares regressions of initial on final estimates displayed in the same figure and coefficients provided in Table 11. The variability in apparent bias causes the regression coefficients to be poorly determined (see slope and intercept confidence intervals in Table 11). Although y-intercepts appear positive for all parameters, there is no strong indication of slope differing from one for this limited dataset.

Figure 11 displays the relationships between CV and apparent bias for these parameters. It should be re-emphasized that the CV's are surrogate values estimated from 1983-95 angler report. The data suggest a possible weak positive relationship between CV and bias in angler days, but for the catch parameters no pattern is evident.

Table 11. —Summary of apparent biases from re-analysis of 14 water-specific results of the provincial follow-up mailing in 1978/79. Coefficients for the regression of the initial estimate (dependent variable) on the final estimate (independent variable) are provided in the lower rows of the table. For each regression coefficient, the 95% confidence interval is provided in parentheses. Regressions are depicted graphically in Figure 11.

	Fishery Parameter			
Description of Bias	**Anglers**	**Angler Days**	**Catch Retained**	**Catch Released**
Range	0.94 to 1.37	0.88 to 1.56	0.71 to 2.52	0.44 to 2.14
Unweighted Mean	1.20	1.24	1.29	1.27
Weighted Mean	1.18	1.18	1.17	1.10
Median	1.20	1.24	1.38	1.17
Slope	**1.12** (1.01, 1.22)	**0.99** (0.76, 1.22)	**0.86** (0.66, 1.05)	**0.68** (0.11, 1.25)
Intercept	**46** (-40, 132)	**819** (-341, 1978)	**116** (18, 215)	**224** (-123, 572)

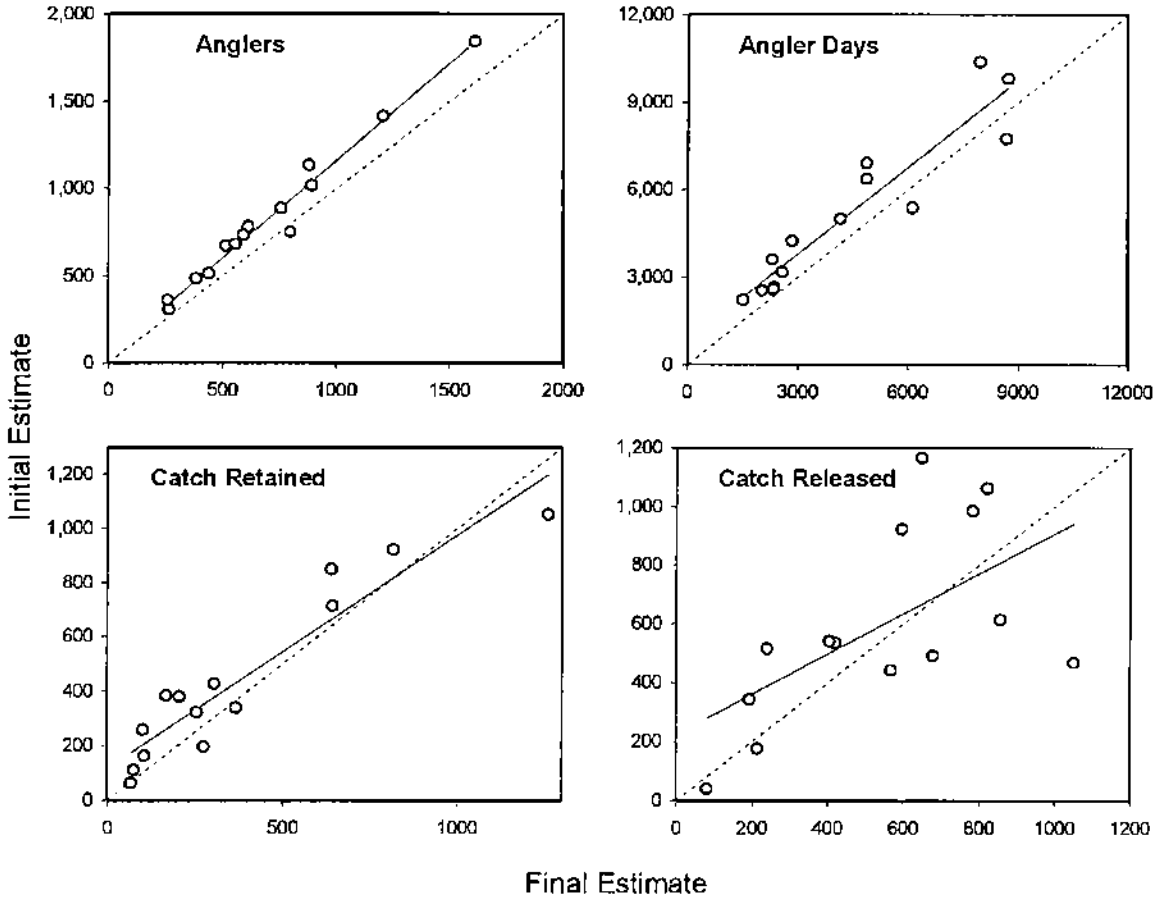

Figure 10.— Comparison of single-mailing SHA fishery parameter estimates to multiple-mailing estimates, for 14 rivers, 1978/79. Regression coefficients are provided in Table 11. The dashed lines indicate Initial = Final, e.g. an unbiased initial estimate.

Table 12.— Comparison of single-mailing SHA fishery parameter estimates to multiple-mailing estimates, for 14 rivers, 1978/79. The column headed **Initial** gives the estimate obtained from the results of the first mailing; **Final** gives the estimate obtained from all mailings; **Bias** is simply Initial ÷ Final. Data obtained from Ford and Narver 1979; estimation methods explained in the text.

River	Anglers			Angler Days			Catch Retained			Catch Released		
	Initial	Final	Bias	Initial	Final	Bias	Initial	Final	Bias	Initial	Final	Bias
Big Qualicum	777	613	**1.27**	3,599	2,311	**1.56**	384	167	**2.30**	513	240	2.14
Campbell	670	515	**1.30**	4,239	2,850	**1.49**	258	102	**2.52**	534	419	1.28
Cowichan	1,413	1,205	**1.17**	10,371	7,951	**1.30**	921	817	**1.13**	1,060	820	1.29
Gold	510	441	**1.16**	2,647	2,364	**1.12**	426	305	**1.40**	490	677	0.72
Nanaimo	730	592	**1.23**	6,900	4,878	**1.41**	711	641	**1.11**	921	596	1.55
Stamp	306	266	**1.15**	2,206	1,518	**1.45**	380	206	**1.84**	539	404	1.33
Englishman	481	384	**1.25**	2,529	2,033	**1.24**	321	256	**1.25**	440	567	0.78
Cheakamus	680	558	**1.22**	3,164	2,581	**1.23**	161	106	**1.53**	342	193	1.77
Fraser	751	797	**0.94**	7,751	8,685	**0.89**	196	275	**0.71**	40	81	0.50
Seymour	356	260	**1.37**	2,564	2,349	**1.09**	111	75	**1.48**	176	214	0.82
Vedder/Chilliwack	1,130	878	**1.29**	6,381	4,880	**1.31**	62	67	**0.92**	1,164	647	1.80
Squamish	1,018	892	**1.14**	4,993	4,174	**1.20**	339	367	**0.92**	612	855	0.72
Thompson	1,841	1,610	**1.14**	9,797	8,723	**1.12**	1,050	1,261	**0.83**	466	1,050	0.44
Bella Coola	884	758	**1.17**	5,375	6,132	**0.88**	849	639	**1.33**	983	783	1.26

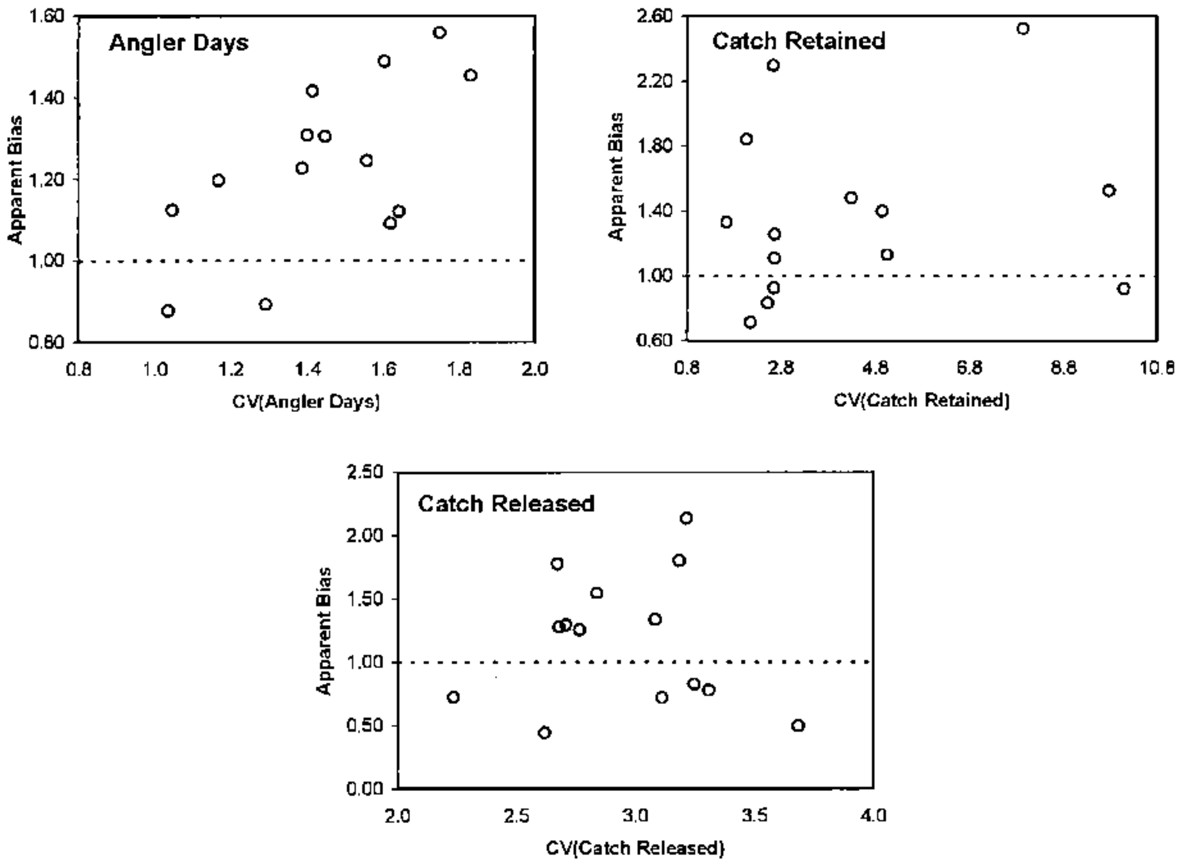

Figure 11.—Coefficients of variation (CV's) for steelhead fishery parameters in relation to the apparent bias displayed by analysis of follow-up contact in 1978/79, for 14 rivers. Parameter CV's estimated for each river from all individual response data, 1983 to 1995. Dashed lines show the position of an unbiased estimate.

3.2. Comparison of SHA and Field Survey Estimates

3.2.1. Characteristics of the Field Survey Dataset

Approximately 97 field-based angling use studies were available for examination. Two studies (Remington 1974; Kier 1980) were rejected immediately as insufficient in scope. Of the remaining 95 studies, 92 yielded one or more parameter estimates comparable to SHA estimates for the same parameter (Table A5; Table A7). The resulting dataset draws from surveys conducted on 26 rivers or river pairs, but is numerically dominated by surveys of three rivers: the Dean (n = 26), Chilko & Chilcotin (n = 12), and Thompson (n = 8).

3.2.1.1 Biases

Sampling designs with known statistical properties have infrequently been used for BC steelhead angler studies. The majority of surveys, especially prior to 1985, sought full coverage within the time period and area judged to include most of the effort and catch. Arbitrary adjustments to compensate for unsampled anglers were occasionally made, based on subjective observations of creel clerks or supervisors. The accuracy of estimates obtained by these techniques is impossible to evaluate in retrospect. Although some techniques used to achieve full coverage can create upward bias in the survey parameter estimates, the net (design) bias associated with full coverage is certainly downward for activity and catch parameters. Simply put, most such studies do not enumerate all of the effort and catch. In attempting only to do so, they fail to provide a means of assessing what has been missed.

Studies which do not attempt full coverage must apply some form of sampling design, if total effort and catch are to be obtained by systematic expansion. The majority of these attempted full coverage on randomly selected days which were stratified according to weekday/weekend, month of the year, or another temporal unit. Again, arbitrary adjustments were sometimes made to alleviate under-sampling. Full coverage even on a single day was still likely unachievable on average, so these estimates are also probable to display a net downward bias of unknown but variable magnitude.

Very occasionally, more complex designs have been applied (Table 13). These designs admit that complete coverage of activity, even for a single day, is impractical for most BC steelhead fisheries. Unlike full-coverage studies, these sampling designs provide a means for assessing the variability in the data and thus uncertainty in parameter estimates. No net design biases are apparent but even among these studies failure to sample the entire season has occurred in many cases, and differentiation of steelhead anglers from individuals pursuing other species is also problematic for some.

Table 13.—BC steelhead angler surveys using documented designs other than full-coverage, licence years 1997 and earlier.

Study	River	Year
Hooton 1976	Gold	1976
Hooton and Lewynsky 1985	Big Qualicum	1976 to 81
Carswell et al. 1986	Campbell; Quinsam	1976 to 80
Clark and Facchin 1986	Chilliwack	1984
Scott and Lewynsky 1985	Chilliwack	1985
Lewynsky and Olmsted 1990	Lower Skeena, Zymoetz, Kispiox, Bulkley	1990
Tallman 1997	Kispiox	1997

3.2.2. Relationship Between Parameter Estimates

3.2.2.1 Residency Pooled

For the 5 fishery parameters of interest, 32 to 82 comparable data pairs were available to examine the relationships of field to SHA estimates. The fishery parameter relationships do not appear to arise from single set of coefficients (ANOVA, F=2870, df = 1 & 310, $p \approx 0$), though pairwise comparisons were not made. Sample sizes, and coefficients for the linear regressions describing these relationships, are given in Table 14. The variability in the data and the linear regressions which describe the relationships are depicted graphically in Figure 12. Figure 13 provides greater detail near the origin, where most of the data lie. As anticipated, for all of the parameter relationships, estimated slopes are greater than one with positive y intercepts (Table 14).

However, as indicated by the relatively large standard errors of regression coefficients for several of the parameters, the relationships are poorly defined due to the variability of the data. This is apparent from the plotted data, and the degree to which the robust regression coefficients differ from the conventional least squares regression coefficients (Table 14).

Table 14.—Conventional least squares and robust least trimmed squares regression coefficients describing the relationships between field creel study estimates (independent variable) and comparable SHA estimates (dependent variable), for five steelhead fishery parameters. All fisheries included. **SE()** indicates the standard error of the indicated parameter; **N** is the sample size. Least trimmed squares estimates are in italics.

Parameter	N	Slope	SE(slope)	Intercept	SE(intercept)
Anglers	32	1.323	0.381	58.1	302.4
	17	*0.947*		*91.1*	
Angler Days	82	1.545	0.042	170.5	171.0
	42	*1.058*		*324.2*	
All Catch	64	1.901	0.069	112.5	183.5
	33	*1.749*		*134.1*	
Retained	74	1.676	0.404	44.9	167.1
	38	*1.267*		*16.7*	
Released	60	1.984	0.083	133.9	174.3
	31	*2.634*		*87.9*	

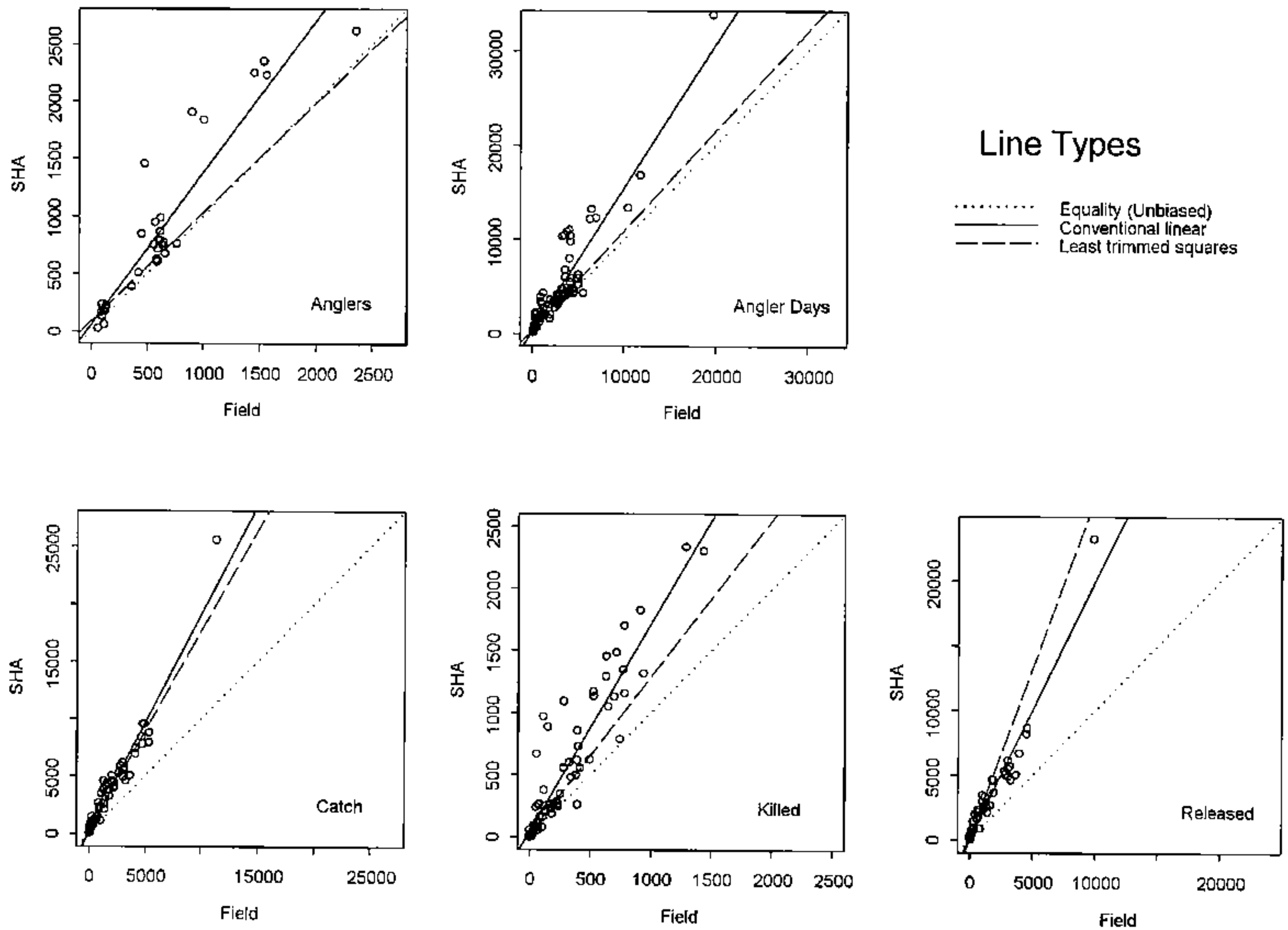

Figure 12.—Comparison of field creel study and SHA estimates for 5 fishery parameters. Depicted regressions include conventional least squares, and a method robust to outliers (least trimmed squares regression). All relevant data are displayed.

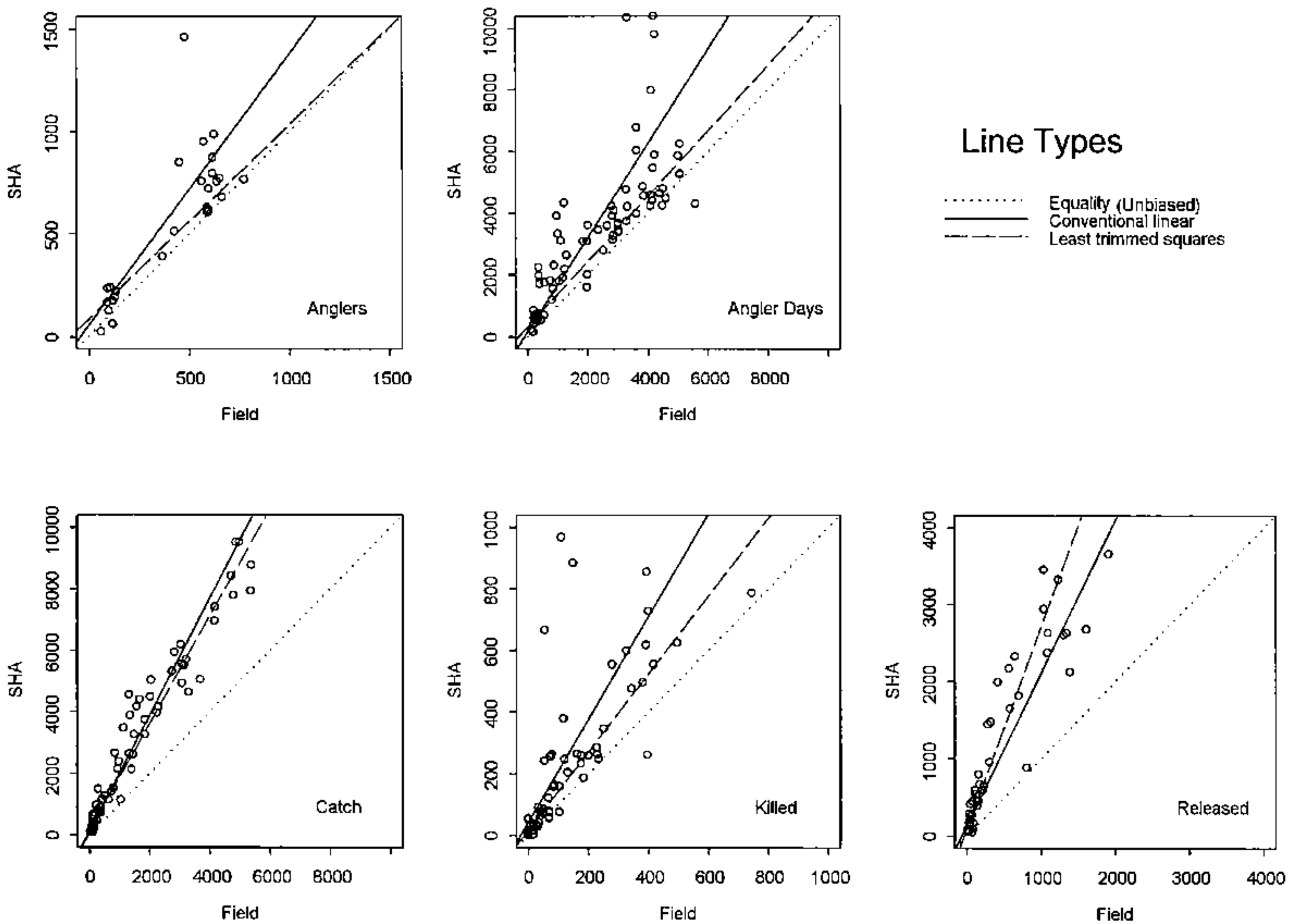

Figure 13.—Comparison of field creel study and SHA estimates for 5 fishery parameters. Data and relationships depicted are the same as for Figure 12, but these panels are scaled differently to provide greater detail in the plot regions where most data lie.

As an alternative to the regression analyses, median ratios of field study estimates to SHA estimates are tabulated in Table 15. Variability is high and the data do not display any obvious relationship between the magnitude of the estimate and the typical discrepancy ratio. Median ratios for quartiles which are dominated by Dean River data (e.g. the second quartile of the number of anglers data and the third quartile of angler days data ---Table 15) are quite different than neighboring quartiles. For these reasons, the median ratio for **All** data points, given in bold for each parameter, is the best general estimate.

Table 15.—Median ratios of field study estimates to comparable SHA estimates, for quartiles of available data for five fishery parameters. Methodological detail provided in the report text. For each parameter the number of data pairs, in each quartile and total, is given as **N**.

Parameter	N	Quartile	SHA Value Range	Median Ratio of Field to SHA (as %)	Median Ratio of SHA to Field (as %)
Anglers	8	1	24 - 233	68	147
	8	2	237 - 720	94	106
	8	3	754 - 949	76	132
	8	4	985 - 2,620	64	156
	32	**All**	**24 - 2620**	**72**	139
Angler Days	21	1	141 - 1780	51	196
	20	2	1,807 - 3,599	62	161
	20	3	3,664 - 4,788	86	116
	21	4	4,851 - 33,877	51	196
	82	**All**	**141 - 33,877**	**62**	161
Catch	16	1	88 - 736	41	244
	16	2	792 - 2,600	42	238
	16	3	2,631 - 5,026	45	222
	16	4	5,044 - 25,572	56	179
	64	**All**	**88 - 25,572**	**49**	204
Retained	19	1	6 - 63	56	179
	18	2	76 - 255	57	175
	18	3	258 - 727	70	143
	19	4	786 - 2,335	49	204
	74	**All**	**6 - 2,335**	**57**	175
Released	15	1	48 - 416	27	370
	15	2	446 - 1,475	26	385
	15	3	1,646 - 3,652	38	263
	15	4	4,597 - 23,270	56	179
	60	**All**	**48 - 23,270**	**36**	278

3.2.2.2 Residency-Specific Comparisons

Residency-specific data were available for field and SHA comparisons of at least one fishery parameter from 43 studies. For a relatively large number of early field studies with residency-specific estimates, matching residency-specific SHA results were not available from either reports or available digital databases. Two types of residency-class contrasts are presented in the following sections: BC residents compared to non-residents, and local residents compared to non-local BC residents.

BC Residents Compared to Non-Residents

Nine to 25 data pairs were available to examine relationships between field and SHA parameter estimates, from results which could be grouped as BC residents and non-residents. Sample sizes and coefficients for the linear regressions describing these relationships are given in Table 16. The variability in the data and the least squares linear regressions which describe the relationships are depicted graphically in Figure 14 through Figure 16. Similar to the residency-pooled data, variability is extreme. Slopes for BC resident data are greater than those for non-residents for all four fishery parameters considered, though none of the differences are statistically significant (Table 16). For three of the four parameters, y-intercepts for the resident group are also greater than for the non-resident class. The implication is that either the upward bias of the SHA estimates is greater for BC residents as a group than for non-residents, or the downward bias of field results is greater for the non-resident group. The data do not allow distinction between these alternatives, though the former hypothesis appears more plausible given other evidence about differences between typical behaviour of resident and non-resident anglers.

Table 16.—Residency-specific least squares regression coefficients describing the relationship between field creel study estimates (independent variable) and comparable SHA estimates (dependent variable). **Int** = intercept, **SE()** indicates the standard error of the indicated parameter; **N** is sample size. **Residency** classes: **R** = all BC residents, **N** = non-residents of BC. For each parameter, the final row gives the results of an F-test for equality of slopes of the regressions : $\mathbf{F_s}$ = F statistic, **df** = degrees of freedom, and **p** = p-value for the test.

Parameter	Residency	N	Slope	SE(slope)	Int	SE(Int)
Anglers	**R**	14	1.328	0.14	48.2	81.8
	N	14	1.087	0.11	24.3	28.4
F_s = 0.586, df = 1 & 24, p = 0.45						
Angler Days	**R**	17	1.611	0.21	464.5	710.7
	N	17	1.108	0.07	197.1	132.9
F_s = 2.086, df = 1 & 30, p = 0.16						
Retained	**R**	25	1.846	0.06	11.3	17.2
	N	25	1.633	0.15	7.9	6.2
F_s = 0.454, df = 1 & 46, p = 0.50						
Released	**R**	9	2.332	0.41	-68.7	297.3
	N	9	1.697	0.29	133.5	590.6
F_s = 0.810, df = 1 & 14, p = 0.38						

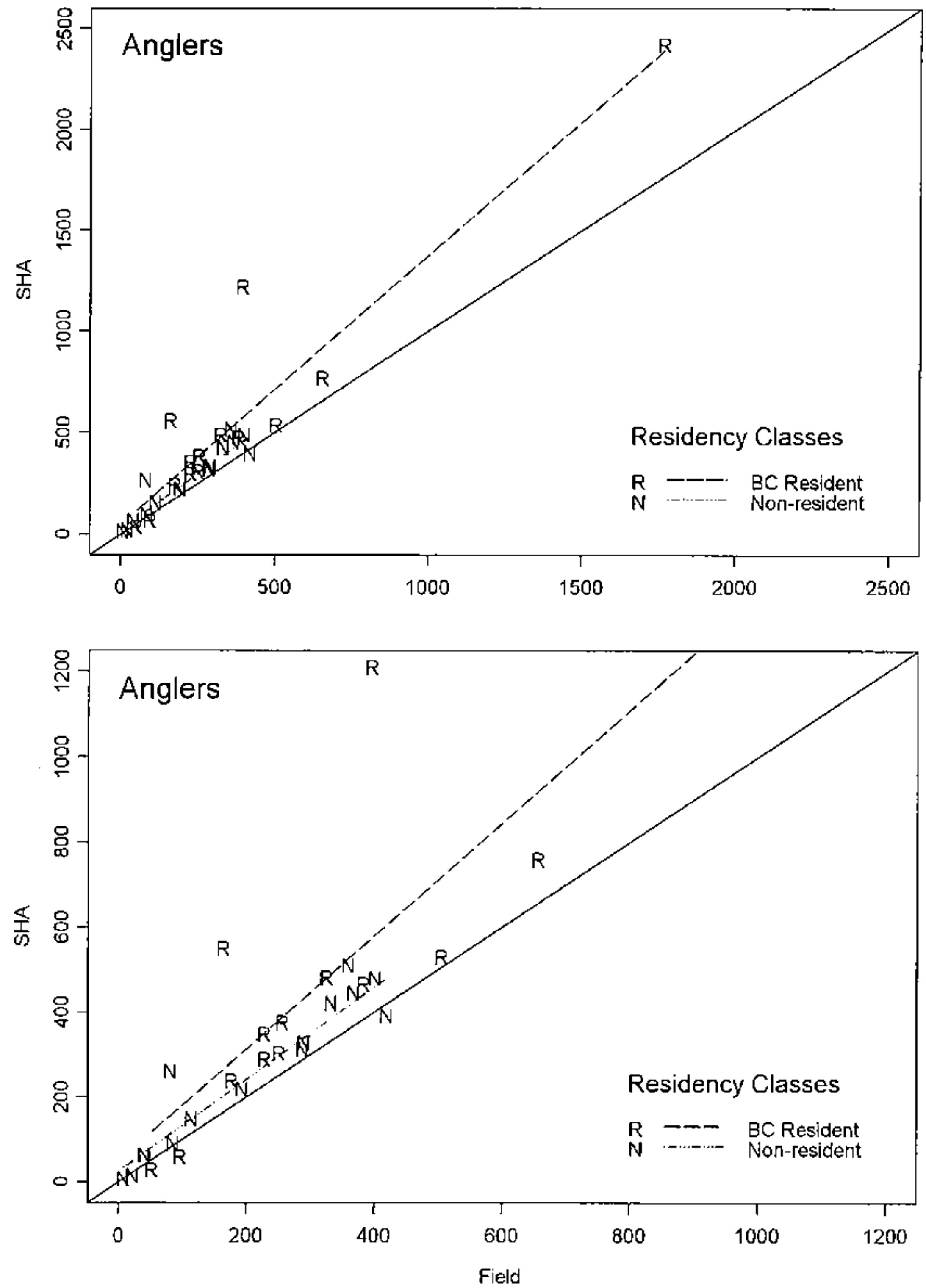

Figure 14.—Comparison of field creel study and SHA estimates of annual number of anglers, BC residents and non-residents. The upper plot shows all available data pairs; the lower plot displays only the region near the origin. Regression coefficients are provided in Table 16. The solid diagonal line depicts equality of field and SHA estimates.

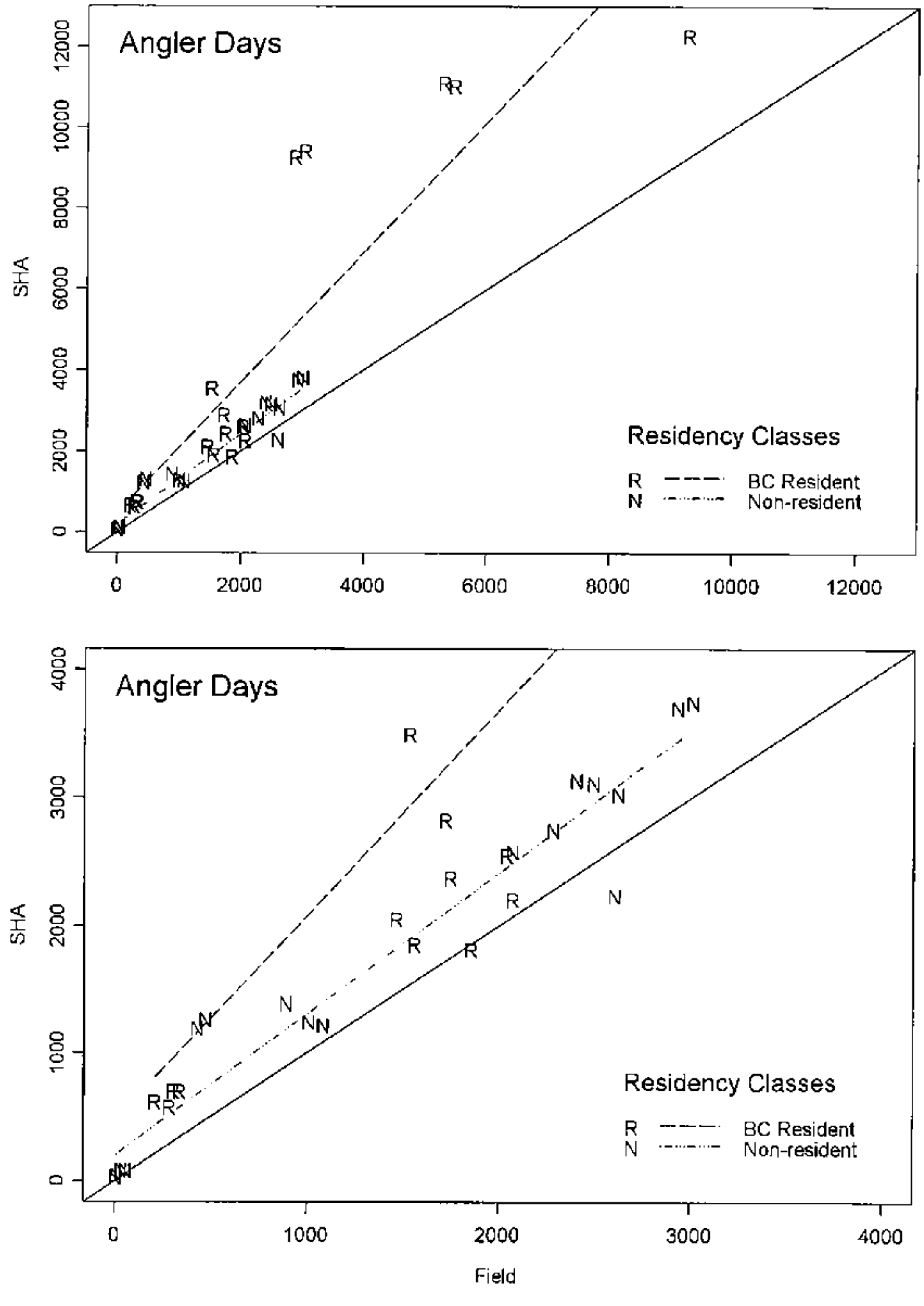

Figure 15.—Comparison of field creel study and SHA estimates of annual number of angler days, BC residents and non-residents. Upper plot shows all available data pairs; lower plot displays only the region near the origin. Regression coefficients are provided in Table 16. The solid diagonal line depicts equality of field and SHA estimates.

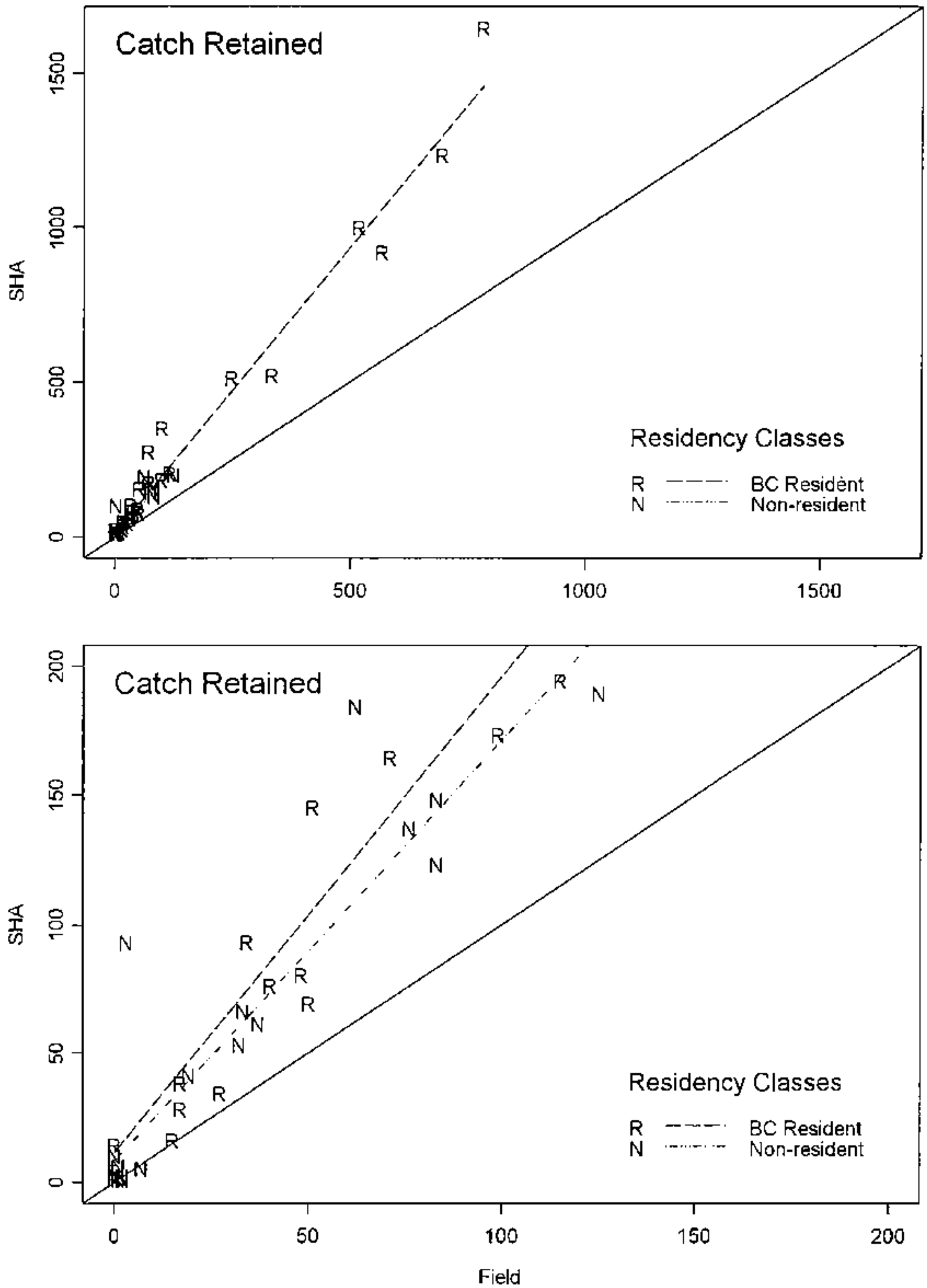

Figure 16.—Relation of field creel study to SHA estimates of annual number of steelhead retained, BC residents and non-residents. Upper panel shows all available data; lower panel displays only the region near the origin. Regression coefficients are provided in Table 16. The solid diagonal line depicts equality of field and SHA estimates.

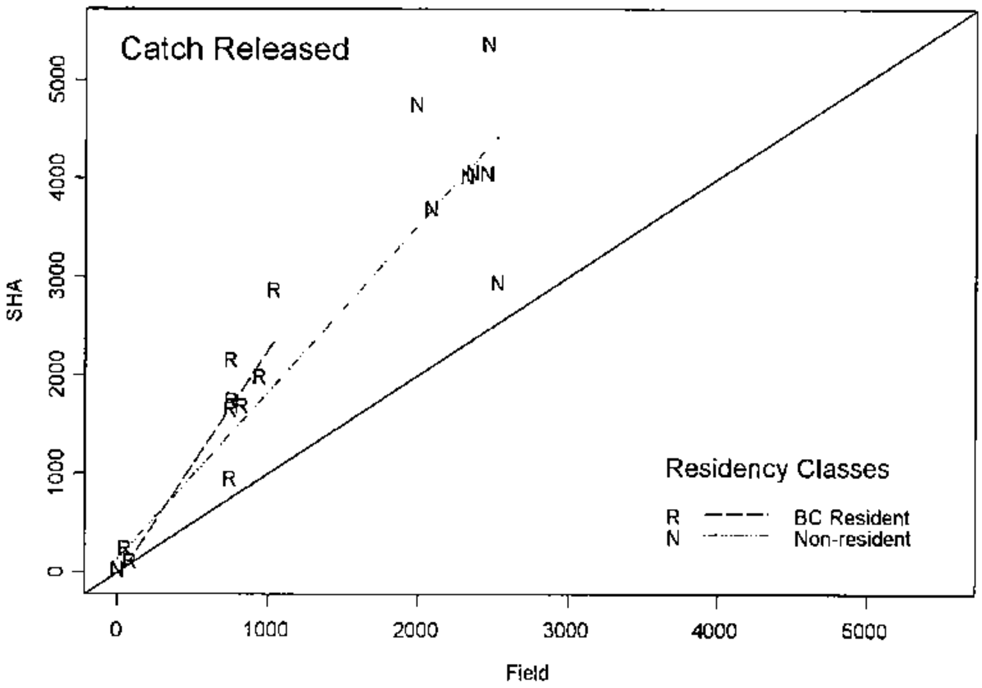

Figure 17.—Comparison of field study and SHA estimates of annual number of steelhead released, BC residents and non-residents. Regression coefficients provided in Table 16. The solid diagonal line depicts equality of field and SHA estimates.

Local Residents Compared to BC Non-Local Residents

Field and SHA results which could be grouped as local residency and BC non-local residency were uncommon in the available datasets (Table 17). The linear regressions which describe the relationships are depicted graphically in Figure 18 and Figure 19. Small sample sizes and high variability prevent any type of conclusion about differences between these residency groups in terms of possible bias of SHA parameter estimates.

Table 17.—Residency-specific least squares regression coefficients describing the relation of field creel study estimates (independent variable) to comparable SHA estimates (dependent variable), for local (**L**) and non-local BC (**B**) resident classes. Abbreviations as for Table 16.

Parameter	Residency	N	Slope	SE(slope)	Int	SE(Int)
Anglers	**L**	7	1.114	0.40	15.3	97.9
	B	7	1.220	0.06	54.6	33.3
F_s = 0.100, df = 1 & 10, p = 0.76						
Retained	**L**	8	2.193	0.77	-1.35	25.8
	B	8	2.157	0.53	-4.49	7.6
F_s = 0.001, df = 1 & 12, p = 0.97						

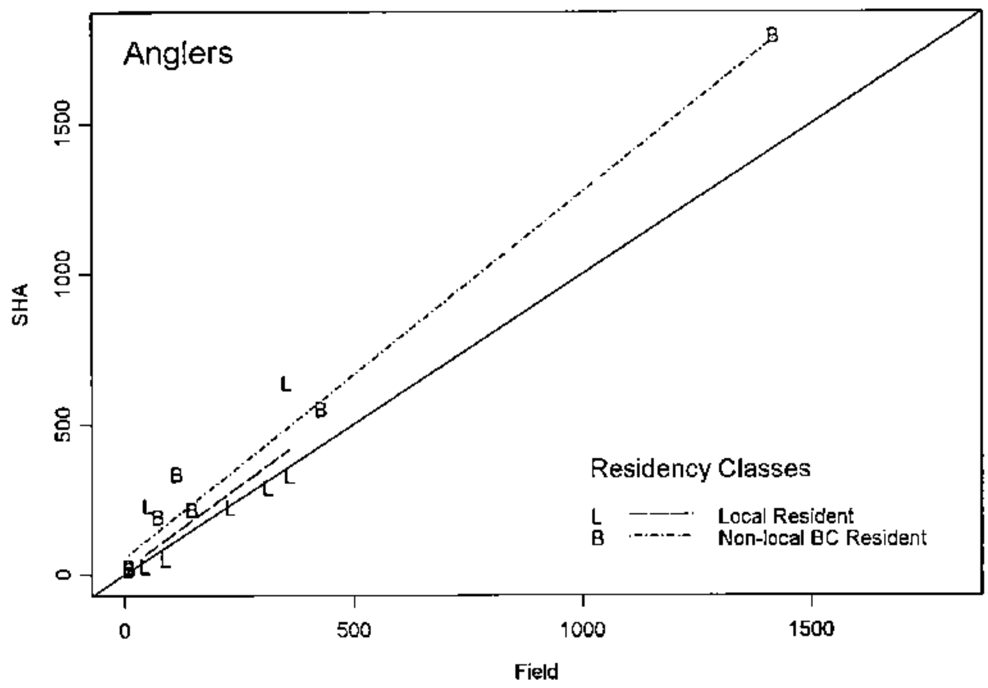

Figure 18.—Relation of field creel study to SHA estimates of annual number of steelhead anglers, local and non-local BC residents. Regression coefficients provided in Table 17.

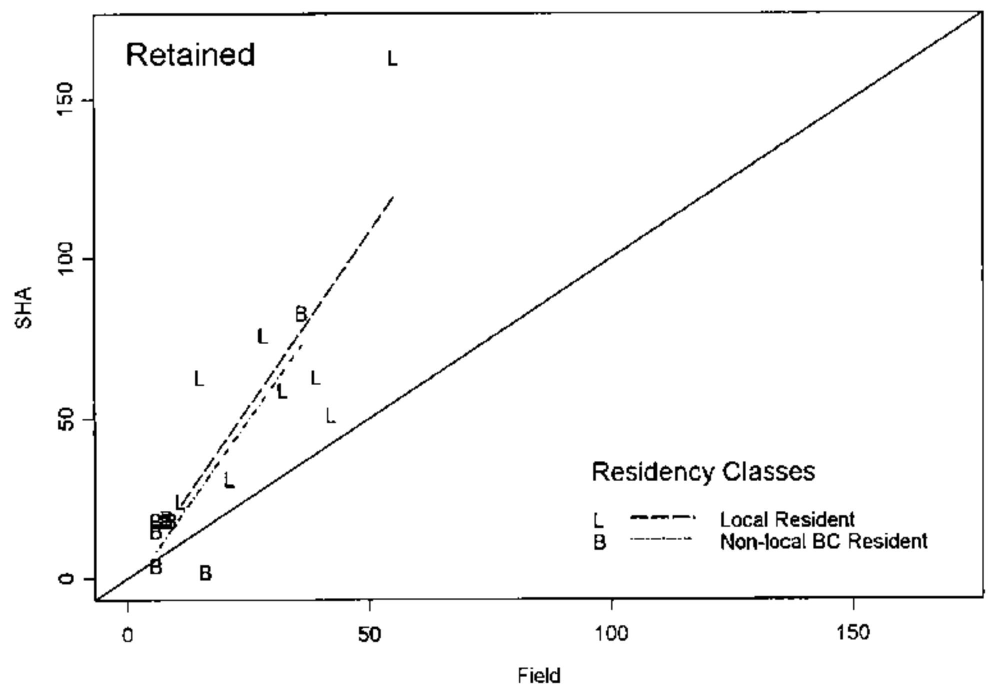

Figure 19.—Relation of field creel study to SHA estimates of annual number of steelhead retained, local and non-local BC residents. Regression coefficients are provided in Table 17.

3.3. Dean River

3.3.1. Characteristics of the Fishery

Characteristics of the Dean River steelhead fishery and angler population are provided in Table A4 (Appendix III). Selected characteristics of the fishery and anglers, and how the values compare to other popular BC steelhead fisheries, appear in Table 18. For each characteristic, the percentile provides a relative placement of the value, in comparison to other fisheries. Percentiles range between 0 and 100; a greater percentile indicates the value is high relative to other fisheries.

The Dean River fishery displays the lowest proportion of local anglers and angler days of the popular fisheries considered. The proportions of angler and angler days contributed by non-local BC residents and non-residents are among the highest of all fisheries. For each residency class, the mean number of days fished per angler are in the top quartile, with the values for non-local BC anglers and non-residents among the highest for all fisheries. Finally, for all residency classes, Dean River anglers fish fewer other streams on average than anglers in almost all other popular BC steelhead fisheries.

Table 18.—Selected characteristics of the Dean River steelhead fishery and anglers, relative to other popular BC steelhead fisheries.

Characteristic	Residency	Value	Percentile
Percentage of anglers	Local (L)	9.2	1
	BC Non-local (B)	34.6	97
	Non-resident (N)	56.2	97
Percentage of angler days	Local (L)	9.9	1
	BC Non-local (B)	36.1	94
	Non-resident (N)	54.0	98
Days per angler	Local (L)	6.8	77
	BC Non-local (B)	6.6	100
	Non-resident (N)	6.1	96
Number of streams angled	Local (L)	1.7	3
	BC Non-local (B)	1.9	3
	Non-resident (N)	1.2	0

3.3.2. Relationship Between Field and SHA Parameter Estimates

The full Dean River dataset provides 11 to 23 comparable data pairs for examination of the relationships of field to SHA parameter estimates. Sample sizes and coefficients for the linear regressions describing these relationships are given in Table 19. The variability in the data and the linear regressions which describe the relationships are depicted graphically in Figure 20. For 4 of the 5 parameter relationships, estimated slopes are greater than one; 3 display positive y intercepts (Table 19). Similar to the province-wide dataset, however, the relatively large standard errors of regression coefficients indicate that relationships are poorly defined. Variability of the SHA estimates is high, relative to the range (spread) of field values. This is apparent from the plotted data, and the degree to which the robust regression fits differ from the conventional least squares regression coefficients (Table 19, Figure 20). Only for the total and released catch parameters do the coefficients appear well-determined and plausible.

Table 19.—Conventional least-squares and robust LTS regression coefficients describing the relationships between field creel study estimates (independent variable) and comparable SHA estimates (dependent variable), Dean River 1972-1995. LTS coefficients are shown in *italics*.

Parameter	N	Slope	SE(slope)	Intercept	SE(Intercept)
Anglers	11	1.292	1.988	-9.7	1181.7
	7	*1.484*		*-133.7*	
Angler Days	23	0.915	0.099	1201.8	347.3
	13	*0.703*		*1618.2*	
All Catch	23	1.428	0.082	1193.8	263.7
	13	*1.462*		*845.0*	
Retained	19	1.674	0.425	-13.3	184.2
	11	*1.276*		*9.6*	
Released	19	1.457	0.108	1053.9	261.5
	11	*1.606*		*644.7*	

The restricted Dean River dataset (1985 to 1995) provides reduced sample sizes (number of data pairs), but reflects refined field procedures and presumably more accurate estimates than those obtained during the 1970s. Sample sizes and coefficients for the linear regressions describing the field / SHA estimate relationships are given in Table 20. The variability in the data and the linear regressions which describe the relationships are depicted graphically in Figure 21. However, as for the previously-considered Dean dataset, variability of the SHA estimates is high relative to the moderate spread of field values. The Dean River fishery has been relatively stable during the period represented by the restricted dataset. Only for the 'retained catch' parameter does the field data provide a wide range of values, and this is an artifact of institution of a mandatory release regulation on the river during the late 1980s.

Table 20.—Conventional least-squares and robust LTS regression coefficients describing the relationships between field creel study estimates (independent variable) and comparable SHA estimates (dependent variable), Dean River 1985-1995. LTS coefficients are shown in *italics*..

Parameter	N	Slope	SE(slope)	Intercept	SE(Intercept)
Anglers	7	0.409	7.80	563.3	4698.1
	5	*0.857*		*210.0*	
Angler Days	11	0.468	0.38	3247.9	1678.0
	6	*1.086*		*58.7*	
All Catch	11	1.662	0.21	306.8	835.4
	6	*1.285*		*1777.2*	
Retained	7	1.266	2.66	7.5	266.2
		NA		*NA*	
Released	7	1.654	0.39	311.6	1347.1
		1.613		*880.9*	

Mean and median ratios of field study estimates to SHA estimates for Dean River datasets are tabulated in Table 21, as an alternative to the regression approach. For both datasets, means and medians for each parameter tend to agree closely. For most parameters, means or medians tend to be higher for the 1985-95 dataset, perhaps reflecting improved accuracy of the recent field estimates. Retained catch estimate ratios are of low utility due to the zero values for recent years. No immediate explanation is available for the increased discrepancy between field and SHA estimates of the number of anglers, for the 1985-95 dataset.

Table 21.—Ratios (as percentages) of field study estimates to comparable SHA estimates, for 5 fishery parameters, Dean River 1972 - 95 and 1985 - 95. **N** gives the number of data pairs; **Med** = median ratio; **Mean** = unweighted mean ratio; **Range** = minimum and maximum ratio.

	1972 - 1995 (%)				1985 - 1995 (%)			
Parameter	**N**	**Med**	**Mean**	**Range**	**N**	**Med**	**Mean**	**Range**
Anglers	11	83	80	60 - 98	7	74	76	60 - 97
Angler Days	23	81	78	49 - 96	11	85	84	60 - 96
All Catch	23	55	53	38 - 71	11	58	58	49 - 67
Retained	19	66	52	0 - 87	7	0	25	0 - 78
Released	19	51	50	35 - 71	7	56	58	49 - 71

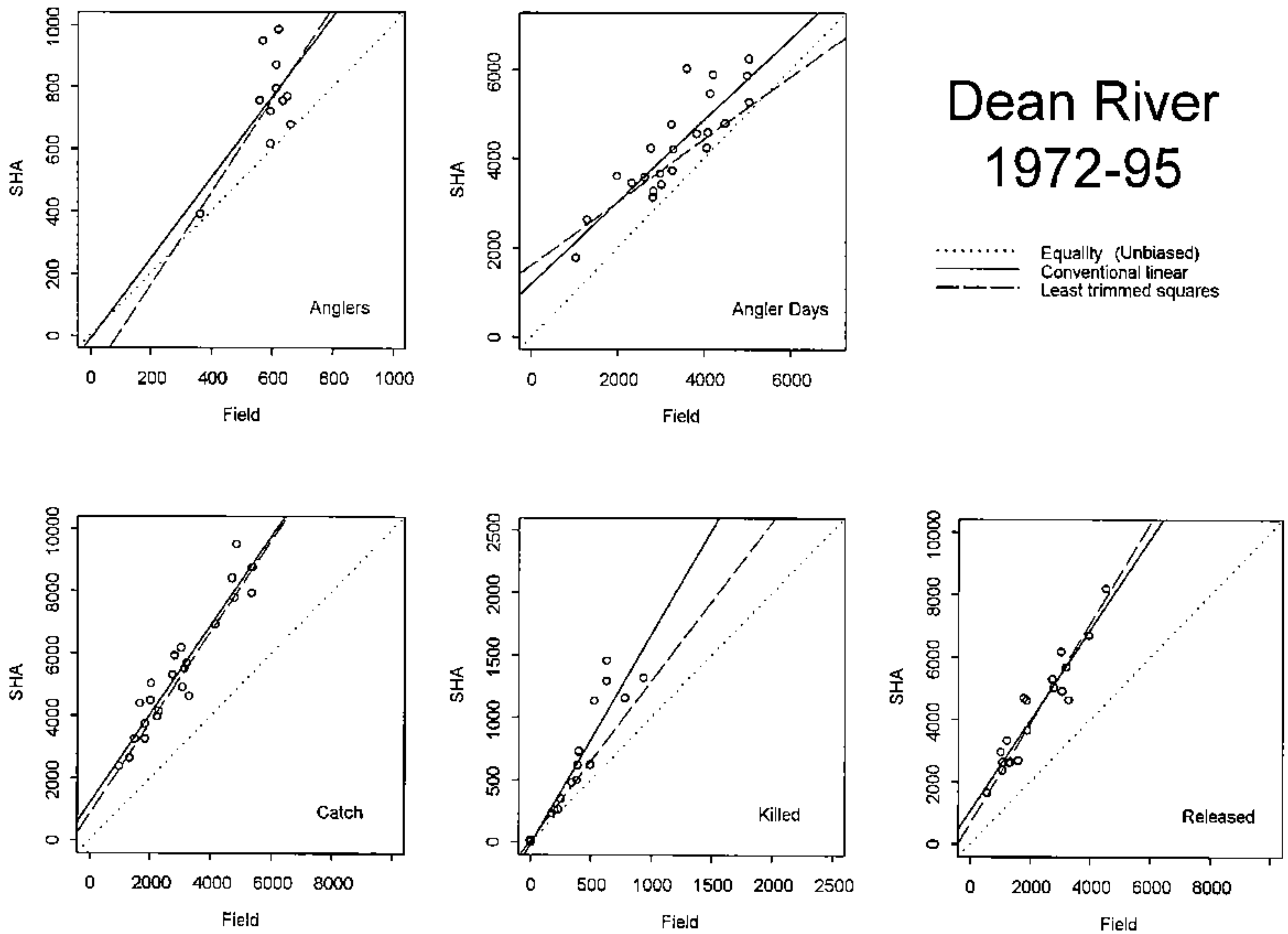

Figure 20.—Comparison of field creel study and SHA estimates for 5 fishery parameters, Dean River 1972 - 95. Depicted regressions are conventional least squares, and a method robust to outliers (least trimmed squares regression). Coefficients are given in Table 19.

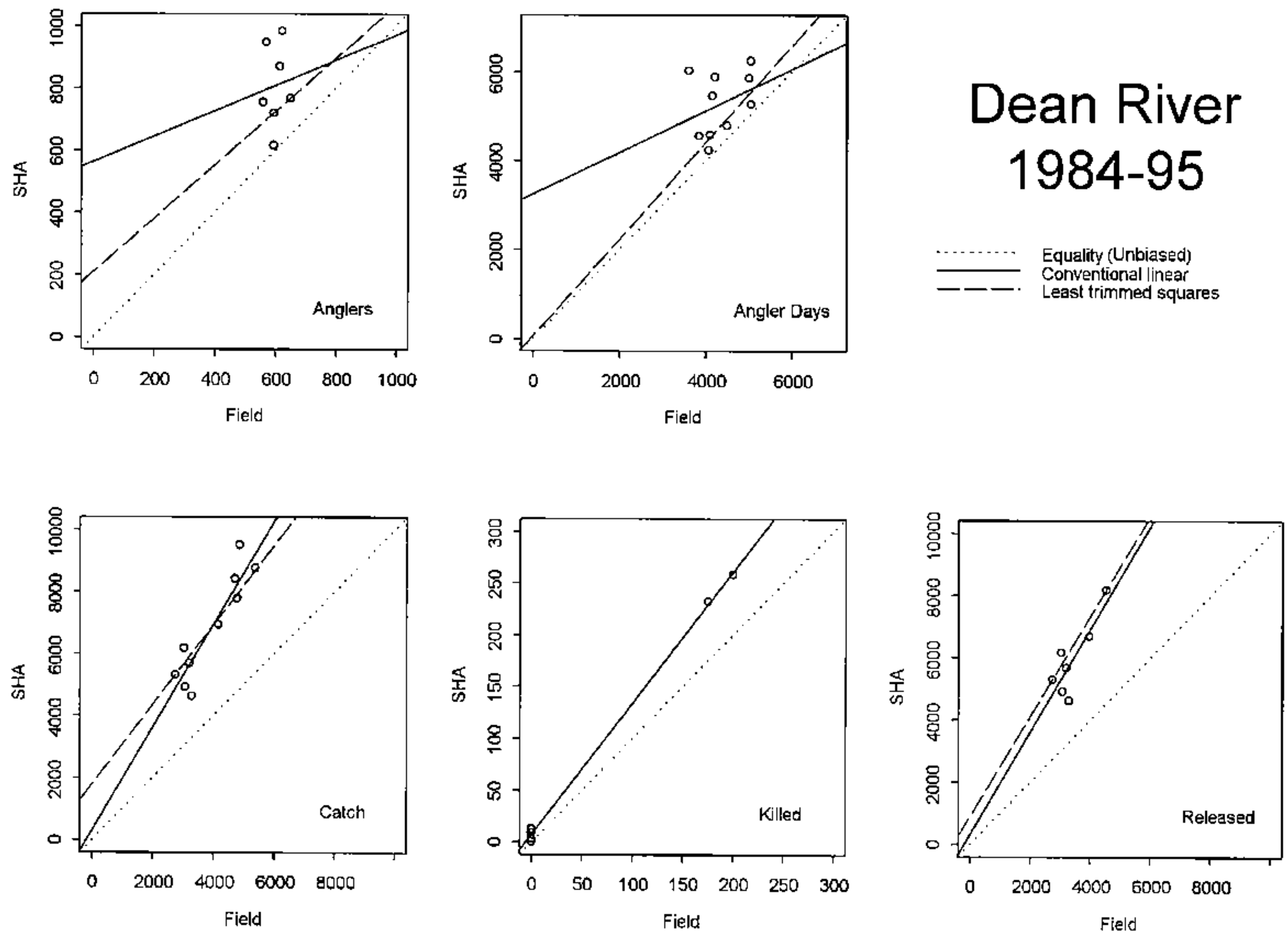

Figure 21.—Comparison of field creel study and SHA estimates for 5 fishery parameters, Dean River 1985-95. Depicted regressions include conventional least squares, and a method robust to outliers (least trimmed squares regression). Coefficients given in Table 20.

Finally, mean SHA and field estimates for the parameters of interest, for each of the 3 residency-pooled datasets, are given in Table 22. The conventional least squares regressions pass through the mean of the independent and dependent variable observations, so the means represent the 'centre' of the data and regression for each parameter. The ratio of the SHA to field estimate at the centre point is one measure of the mean discrepancy for the dataset. This constitutes a weighted mean, and if the relationship is linear with a non-zero intercept, the ratio is only valid at the centre itself. The mean discrepancies are presented as a simplified depiction of the typical difference in discrepancy between the three datasets. As expected, the province-wide dataset typically displays the highest discrepancy and the recent Dean dataset the lowest. Only for number of anglers does the complete Dean dataset present the lowest discrepancy. If the recent Dean field data are as accurate as believed, the mean discrepancies represent the approximate bias of the SHA-estimated Dean fishery parameters under current conditions.

Table 22.—Mean SHA and field estimates and weighted mean discrepancy for five fishery parameters. Results for 3 datasets are presented: **Province**-wide data, and the complete Dean and recent Dean data. Columns are: **SHA** = mean value of SHA estimates; **Field** = mean value of field estimates; **D** = weighted mean discrepancy, calculated as SHA/Field.

	Province			**Dean 1972-95**			**Dean 1985-95**		
	SHA	**Field**	**D**	**SHA**	**Field**	**D**	**SHA**	**Field**	**D**
Anglers	866	611	**1.42**	752	590	**1.28**	809	601	**1.35**
Angler Days	4602	2904	**1.58**	4275	3358	**1.27**	5148	4263	**1.21**
Total Catch	3474	1769	**1.96**	5420	2960	**1.83**	6911	4044	**1.71**
Retained	492	269	**1.83**	548	336	**1.63**	75	54	**1.40**
Released	2592	1239	**2.09**	4225	2177	**1.94**	5930	3397	**1.75**

4. Discussion

4.1. Precision of SHA Parameter Estimates

Imprecision in fishery parameter estimates from the SHA results from three main factors which interact in a variable manner:

1. response samples constitute a relatively small proportion of the angler population,
2. reported participation and success vary greatly among individual anglers, and
3. many fisheries are conducted by a relatively small number of individuals, with total activity and catch dominated by an even smaller number of anglers.

Random re-sampling of individual response data gave standard errors for SHA parameter estimates whose relative magnitude was inversely correlated with the estimated value of the parameter, as would be expected for such an estimator. Resulting 95% confidence interval widths varied from two times the parameter estimate for values at the lower margin of the range of estimate sizes, to roughly one-third the estimate at the upper margin. Precision varies substantially among the parameters and residency classes. Highest precision is achieved for non-resident estimates because of the higher sampling proportion applied. Of the directly estimated parameters, precision is lower for the catch parameters than for those related to effort, mainly due to higher underlying variance in the catch data.

The acceptability of an estimator's precision can only be judged with reference to its intended use. As far as could be determined, explicit consideration of the intended precision of SHA estimates has not been recorded in reports which document the survey. Assessment of whether the SHA is achieving the desired precision is therefor not possible. Precision is clearly correlated with sample size, and the trade-off with increased cost has always been an important factor in angler survey design. To the present, management application of SHA results by the Fisheries Branch has been relatively non-quantitative. In the current management arena, the desire to apply SHA estimates alongside statistics which are presumed more precise (e.g. Bulkley River AUP 1998) requires reconsideration of the precision of SHA results. Randomized re-sampling offers the opportunity to estimate SHA precision, as well as explore how precision might change under a different sampling regime. At a minimum, precision should be explicitly considered and discussed in a quantitative manner in any steelhead fishery management plan which proposes to apply SHA estimates for any purpose, be it trend-monitoring or otherwise. In reality, the issue of precision of SHA estimates will continue to be secondary to concerns about bias, which are discussed next.

4.2. Bias of SHA Parameter Estimates

Two types of biases have been repeatedly documented to affect the results of jurisdiction-wide mail angler surveys covering multiple months' activity: nonresponse bias and recall bias (Brown 1991). Limited evidence about how each of these sources of bias may influence SHA estimates is currently available. Follow-up contact results from 1978/79 and 1982/83 were reanalyzed for nonresponse bias, and a discussion of the implications is given in subsequent paragraphs of this section. Material is also available for assessing recall bias, in the form of a unique study conducted on the Thompson River in 1984. Results of the study are not presented under this cover, but the implications for recall bias gained by preliminary review of the dataset are discussed below.

4.2.1. Recall Bias

Long recall periods for mail and phone surveys typically result in overestimates of effort and catch (Brown 1991). Anglers experience difficulty referencing which time period their trips fell within, and they err on the side of including trips that fell outside a given time period (Brown 1991). Preliminary analysis of data from a unique study on the Thompson River in 1984 suggests that this is a factor which contributes substantially to upward bias of SHA results. During an intensive creel survey, angler licence numbers were recorded along with the data describing their activity on-river. Individual SHA responses could then be compared to on-site "real-time" data. Unfortunately, the field data are truncated or censored, meaning that potential activity after the final field check of an angler is unknown. A statistically valid adjustment for this factor was beyond the scope of this study, and prevented the summary and presentation of the comparative data here. As well, no means are available for assessing the effect of multiple-contact field studies such as the Thompson angler survey on the representativeness of corresponding SHA responses. Repeated questioning by creel survey technicians might be expected to influence anglers' ability to accurately recall their angling experience, but there is no evidence to confront this conjecture. However, the number of SHA respondents who reported angling the Thompson River in 1984 but were never detected by the creel survey was much higher than could have occurred by chance. The implication is that a significant number of anglers incorrectly recalled having angled the Thompson in 1984. It is clear that angler recall is a factor in the bias of SHA estimates, and it suggested that complete analysis of the 1984 Thompson dataset would provide a starting point for further investigation.

4.2.2. Nonresponse Bias

Reanalysis of follow-up contact data suggests that the typical nonresponse bias of SHA parameter estimates obtained by a single mailing tends to lie within the range of + 20 to + 30 %. Aggregate results from 1978/79 and 1982/83, as well as a limited set of water-specific results for 1978/79, display apparent first-result biases of this magnitude. Water-specific results displayed a wide range of apparent nonresponse bias. Individual response data were not available for either secondary-contact dataset, so no method was available for constructing confidence intervals for the apparent bias. Given the known variance in response data, the variability in apparent bias estimated from such data appears plausible. Recovery of the raw data from the 1978/79 study would allow estimation of the precision of water-specific results by simulation, as well as extension of the analysis to a larger number of individual waters than the 14 reported in the study. It might also allow investigation of whether nonresponse bias varies among residency groups, which could cause differential bias between rivers given the wide variation in residency composition of BC steelhead fisheries.

Survey bias stemming from the reduced tendency for less active and successful anglers to respond to voluntary questionnaires has been well documented in the fisheries management literature (Brown 1991). Although some studies have reported that respondent and non-respondent groups did not appear to differ with respect to the parameters of interest (Brown

1991), the balance of evidence suggests that nonresponse bias must be considered in any voluntary survey of angling activity and success. The follow-up contact reanalysis reported here confirms that the SHA estimates are subject to substantial nonresponse effects, and diverges from the original interpretation of the follow-up data which concluded that secondary contact indicated minimal nonresponse bias in the SHA (Ford and Narver 1979; Billings 1983). The original interpretation implicitly assumed that the secondary response data were representative of the entire population of nonrespondents to the first contact. The present analysis assumes that the results of secondary response are indicative of a trend in per-respondent parameter values, which would continue to change in a linear manner if the sample could be extended to all survey recipients. The interpretations are thus based on very different underlying models of angler behaviour and/or response probability. The unstated model of angler behaviour assumed by the original interpretation is easily rejected as unlikely. The model implied by the re-analysis (Filion's method) is also unstated, but is computational rather than statistical or probabilistic and may itself be no more plausible than the original one. In fact, the Filion estimator is unlikely to be unbiased, even were its implicit model accurate. The available data are derived from a single follow-up contact and thus do not allow assessment of linearity in per-respondent parameter values implied by Filion's method, which would require at least two follow-ups. Regardless, apparent linearity is still no guarantee of an accurate estimate. There are superficial similarities to the Leslie removal estimator of population size; removal data often appear quite linear while severely underestimating population size. The fact that the reanalyzed data provide estimates of SHA bias which are similar to other subjective ideas about bias, should not be interpreted as implying that the re-estimates are themselves accurate.

This discussion of apparent bias may seem to belabour the possible weaknesses of follow-up contact methods. Follow-up contact is certainly worthwhile, and could be used to generate SHA estimates which would be typically less biased than by the current method, without completely redesigning the SHA procedure or abandoning the perceived value of a time series of initial-contact SHA estimates as a long-term index of steelhead fishery characteristics. However, such an approach will do little to clarify the characteristics of the angler population which lead to such severe non-response bias, leaving unanswered the question of the remaining inaccuracy including recall bias. Sampling nonrespondents by an alternative contact method, such as by telephone, has been suggested as "the only sound method of estimating non-response bias" (Pollock et al. 1994). This approach neglects the possible effect of the contact method itself. It is easy to envision that some anglers might respond differently to an anonymous postal questionnaire than to a person-to-person telephone survey. A factorial design for initial and follow-up contact could alleviate this problem, and might be needed only occasionally to maintain an aggregate adjustment factor. In summary, a thorough review of the social science literature concerning the design of mail survey follow-up contact would be useful before an attempt to estimate or reduce bias in the SHA is undertaken by this method. Recovery of the raw data from the 1978/79 follow-up study would allow Monte Carlo simulation to be used to examine the precision of any proposed approach.

4.3. Net Bias: Comparison to Field Studies

Comparison of SHA estimates to field-based angler survey results was a prime motivator for this study. Such comparisons have typically documented large differences in fishery parameter estimates between the two methods. Compilation of all such comparative data was viewed as one potential approach to 'calibration' of the net bias from all sources for SHA estimates. In particular, the Dean River dataset was viewed as potentially providing an accurate standard for assessing SHA bias. For reasons discussed next, neither the Dean River dataset nor the province-wide dataset appear to be suited to assessment of SHA estimate bias.

4.3.1. Dean River

The Dean River series superficially appears to be the field survey dataset most suited to comparison with the SHA. The logistics of the fishery allow a near-complete tallying of effort and catch, with more than 25 years data compiled to the present and typical downward bias in the neighborhood of 5% or less. Data from early years of the full 1972-1995 dataset may have been less complete, due to unquantified activity by loggers and some guided anglers. However, since the mid-1980s, virtually all steelhead angling on the Dean has been tabulated. Weighted mean upward discrepancy of SHA to field estimates for the 1985-95 dataset (35% for number of anglers, 21% for number of angler days, 71% for total catch, 41% for retained catch, and 75% for released catch) might be interpreted as the best available estimates of SHA bias.

However, the Dean River series does not appear to provide an adequate calibration for the bias of SHA results for other provincial steelhead fisheries. Dean River fishery participants are not typical of provincial steelhead anglers, either in terms of their activity on the Dean or other factors which might affect their SHA responses, such as participation in other BC steelhead fisheries. The Dean River fishery lacks a substantial local angler component, which may reduce the severity of non-response bias. The majority of Dean participants angle steelhead in BC only on the Dean River in any one licence year. Most Dean River anglers make a single discrete trip to the river in a given year. As well, every angler completes a survey form at the end of a Dean River visit. Each of the latter 3 factors could serve to anchor the trip details more firmly in anglers' memories, easing recall bias. Finally, steelhead fisheries in British Columbia are highly variable, in terms of the effort and catch parameters estimated by the SHA. The relative stability of the Dean fishery limits the range of values it has displayed; the range is insufficient relative to the spread for other fisheries in British Columbia. In other words, extension of Dean results to other fisheries would require extrapolation far beyond values displayed by the Dean dataset. Such extrapolation would be statistically invalid and potentially dangerous by any standard of analysis.

4.3.2. Province-wide Dataset

In most cases across the province, SHA estimates of effort and catch are substantially greater than those resulting from field studies. The proportional discrepancy is higher for catch than effort, so the mean catch per effort (CPE) estimate from the SHA is typically higher than for field studies as well. This pattern was noted immediately and repeatedly in specific studies during the first decade of the SHA (e.g. Hemus 1974; Hooton 1976), and additional examples have been compiled to the present (e.g. Wilders 1995). The current report compiles all data available to present, and supports conclusions reached by previous authors.

The clear difficulty is that nearly all field-based surveys of BC steelhead fisheries have utilized techniques and designs which tend to create downward bias in their estimates of angling effort and catch. The methods used for such studies have not typically allowed estimation of the magnitude of the underestimation, which thus remains unknown and presumably quite variable. As a result, existing field survey data offer a poor baseline for assessing bias in the SHA. Simply put, SHA estimates are certainly biased upward, but field survey results have been predominantly biased downward, likely in an inconsistent fashion. Reality is somewhere between, but difficult to locate with any confidence by using the existing data.

More recently, BC steelhead angler surveys have tended to use designs with precision which is statistically well defined as long as sampling assumptions are met. Even among these studies, however, angling during the "shoulders" of the steelhead angling season or on less-utilized reaches has often remained unquantified, and distinction of anglers targeting other species has been problematic. Both factors limit their utility as a true baseline for comparison to the SHA. Only the collection of full-season spatially complete data limited to steelhead anglers will allow field studies to provide a convincing basis for assessment of SHA estimate bias.

4.4. Summary

Mail surveys are simple and relatively inexpensive for their breadth of scope (Brown 1991; Pollock et al. 1994). No other affordable method would be capable of providing regular and consistent information about the hundreds of spatially and temporally diffuse recreational fisheries for steelhead in British Columbia. The SHA has provided an ongoing time series of effort and catch estimates which has been a helpful reference for provincial fishery managers.

Even when biased, estimates of population parameters can be used as indices of the relevant parameter if bias is consistent (stable or stationary) with respect to time or other varying conditions. Available information provides minimal basis for assessing the validity of the SHA as a stable index of effort and catch. Recent evidence has failed to confirm one hypothesized time-linked source of downward bias, a decline in the proportion of steelhead anglers purchasing annual species licences. However, observations which address this issue (Tallman 1996; Morten and Parken 1998) have been made on classified waters, where possession of a steelhead stamp is required in order to obtain the mandatory classified water licence. These data thus do not confront the hypothesis that a declining proportion of local resident participants in unclassified steelhead fisheries are purchasing steelhead stamps.

Notwithstanding the previous discussion, the value of the SHA as a trend index cannot be judged in isolation from other (mis)uses of the survey parameter estimates. The SHA estimate series now represents the "best available information" about activity and harvest which have occurred during previous years. Maintaining such an information base without establishing its limitations is a potentially hazardous policy for any management agency. Brown (1991) is worth quoting extensively on this point:

> " ... *the use of (annual single contact) data for trend purposes is a classic rationalization. The problem is that cheap, biased data are not cheap. They are barely affordable ... Socioeconomic data are most in demand when a policy issue, conflict or significant environmental impact occurs. In general, effort, harvest, expenditures or other economic valuation data are wanted immediately— there is neither time nor money for a new study. In this case, estimates from statewide mail surveys are used for want of anything better. Indeed, during a crisis, they may be regarded as numerically accurate. ... This is an example of the abuse of mail survey data.*"

The current steelhead fishery management arena offers three examples where application of upward-biased SHA parameter estimates could prove misleading or even damaging. First, use of SHA effort estimates to establish acceptable levels of activity on a particular water would be valid only under very restricted conditions, whereby SHA results would be understood to constitute an index only, with periodic assessment of stability of the index a necessity. Second, if SHA estimates were used alongside guide reports to establish the proportion of all angling activity conducted by guided anglers, this type of application must also be understood to provide a very rough index only and not an absolute proportion. In both cases, estimates of total activity obtained by methods other than the SHA could not be substituted. Third, SHA estimates of steelhead harvests sustained during the past would provide a badly unbalanced and potentially damaging standard for resumption of harvest in BC recreational steelhead fisheries. The general implication is that abandonment of the SHA time-series without attempting to address the issues of its bias and accuracy could prove even more destructive than a continuance of the present methodology, given the potential misuses of the data.

5. RECOMMENDATIONS

1. The Ministry of Fisheries and Ministry of Environment should reassess the desired accuracy of SHA estimates and the three-way tradeoff of cost, bias and precision. Regional staff should be consulted as to the potential applications for SHA data and the needs in terms of accuracy. Existing data and costs per questionnaire could then be used to examine scenarios for decreasing bias by including follow-up contact as an ongoing component of the SHA. Allocation of funding to follow-up contact could require lowering the first-mailing sample proportion, but the reduced precision might be acceptable when balanced against reduced bias.

2. SHA parameter estimates should be reported with their standard errors or confidence intervals. Standard errors could be most easily obtained by Monte Carlo methods such as the bootstrap, although an analytical approach might also be possible.

3. Data from the 1978/79 and 1982/83 follow-up contact should be recovered and subjected to complete re-analysis. Assessment of nonresponse bias for a large number of fisheries would provide a better basis for understanding this component of SHA inaccuracy. The data would also provide a basis for designing future follow-up contact to alleviate nonresponse bias.

4. Data from the 1984 Thompson River study should be thoroughly analyzed, for the understanding that it will provide about both recall bias and nonresponse bias. A statistically rigorous approach to alleviating truncation or censoring of the field data will be necessary.

5. A province-wide follow-up contact study should be conducted, using multiple contact methods within a factorial design, to more thoroughly assess the extent and properties of nonresponse bias. Design of the follow-up study should utilize the existing dataset to provide expectations of the statistical distributions involved, and explicitly-stated objectives for study power and estimate precision. The follow-up study should be conducted concurrently with at least one field-based study where angler activity and success can be matched with individual angler responses to the SHA.

6. SHA estimates of harvest and catch should be explicitly labeled as indices when cited in management contexts, until the (in)accuracy of the SHA is more fully understood. Particular care should be taken when SHA estimates are provided alongside effort and catch data from other sources.

6. ACKNOWLEDGMENTS

Dana Atagi collected creel survey references from BCE regional offices. Pat Fraser provided the digital database for the Dean River fishery, as well as explanation of its format. Rob Bison and Al Caverly provided the 1984 Thompson River dataset. Sue Billings and George Scholten provided the Steelhead Harvest Analysis digital databases, and some explanations of methodology. Mark Beere assisted with the extraction of data from reports and printouts on file at Skeena Region. Sincere thanks are extended to all.

HABITAT
CONSERVATION
TRUST FUND

This project was funded by BC Environment's Habitat Conservation Trust Fund and developed by personnel of BC Environment. The Habitat Conservation Trust Fund was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia. Hunters, anglers, trappers and guides contribute to HCTF enhancement projects through licence surcharges. Tax deductible donations to assist in the work of HCTF are welcome.

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APPENDIX I. BOOTSTRAP SOURCE CODE

```
Function SHABootstrap()

' get array of estimates (stream and year) to be made
SelStr = "SELECT DISTINCTROW [Estimates].[Year], [Estimates].[Stream] FROM [Estimates]"
Set dbs = CurrentDb
Set Datasets = dbs.OpenRecordset(SelStr, dbOpenSnapshot)
Fisheries = Datasets.GetRows(5000)
estimates = UBound(Fisheries, 2)
Set dbs = Nothing
Set Responses = Nothing

For dataset = 0 To estimates

  EYear = Fisheries(0, dataset): EStream = Fisheries(1, dataset)
  SelStr = "SELECT DISTINCTROW [SortedRawData].[RES_AREA], [SortedRawData].[DAYS],  [SortedRawData].[KILL],
[SortedRawData].[REL] FROM [SortedRawData]"
  WherePart = "WHERE [SortedRawData].[YEAR] = " & EYear & " AND [SortedRawData].[STREAM] = '" & _
      EStream & "'"
  SelStr = SelStr & WherePart

  Set dbs = CurrentDb
  Set Responses = dbs.OpenRecordset(SelStr, dbOpenSnapshot)
  records = Responses.GetRows(5000)
  NumRet = UBound(records, 2)
  Set dbs = Nothing
  Set Responses = Nothing

  '0 is RES_AREA, 1 is DAYS, 2 is KILL, 3 is REL
  'resampling by residency; next code looks at the sample, counts up lines in each res class
  Erase allres(): Erase allmeans(): Erase resRA(): ct = 0
  Erase sdRA(): Erase estRA(): Erase datRA(): Erase redatRA()

  resRA(0, 1) = 1: resRA(0, 2) = 0
  resRA(0, 0) = records(0, 0)
  For i = 1 To NumRet
    If records(0, i) <> records(0, i - 1) Then
      ct = ct + 1
      resRA(ct, 0) = records(0, i)
```

```
    resRA(ct, 2) = i
  End If
  resRA(ct, 1) = resRA(ct, 1) + 1
Next i

Lcl = DLookup("[REGION CODE]", "Lookup Stream Codes", "[STREAM CODE] = '" & EStream & "'")

'go through the res classes and make each estimate
For j = 0 To 9

  'col 0 is res type, col 1 is sample, col 2 is start line
  'Debug.Print j, resRA(j, 0), resRA(j, 1), resRA(j, 2)
  If resRA(j, 1) > 0 Then
    'if there are residents in this slot
    licences = DLookup("[LICENSEES]", "QUESTIONNAIRE STATISTICS", "[YEAR] = " & EYear & " AND [RES_AREACD]
                = '" & resRA(j, 0) & "'")
    respond = DLookup("[RESPONSES]", "QUESTIONNAIRE STATISTICS", "[YEAR] = " & EYear & " AND [RES_AREACD]
                = '" & resRA(j, 0) & "'")
    active = DLookup("[R_ACTIVE]", "QUESTIONNAIRE STATISTICS", "[YEAR] = " & EYear & " AND [RES_AREACD] =
                '" & resRA(j, 0) & "'")
    undelivered = DLookup("[UNDELIVERD]", "QUESTIONNAIRE STATISTICS", "[YEAR] = " & EYear & " AND
                [RES_AREACD] = '" & resRA(j, 0) & "'")
    mailed = DLookup("[MAILED]", "QUESTIONNAIRE STATISTICS", "[YEAR] = " & EYear & " AND [RES_AREACD] = '"
                & resRA(j, 0) & "'")

    'probabilistic approach to how many responses to generate
    ProbResp = respond / (mailed - undelivered)
    ProbActive = active / respond
    ProbRiver = resRA(j, 1) / active

    For k = 1 To numruns: ' for each simulation run
      expand = 0: responders = 0: activeresponders = 0
      For m = 1 To (mailed - undelivered)
        Randomize Timer
        If Rnd < ProbResp Then
          'response occurs
          responders = responders + 1
          Randomize Timer
          If Rnd < ProbActive Then
            'responder was active
            activeresponders = activeresponders + 1
```

```
            Randomize Timer
            If Rnd < ProbRiver Then
               Randomize Timer
               pick = Int(Rnd * (resRA(j, 1)))
               For n = 1 To 3
                 datRA(j, k, n) = datRA(j, k, n) + records(n, pick + resRA(j, 2))
               Next n
               datRA(j, k, 4) = datRA(j, k, 4) + 1
            End If
          End If
        End If
      Next m
      expand = licences / responders
      For n = 1 To 4
        datRA(j, k, n) = datRA(j, k, n) * expand
      Next n
     Next k: ' next sim run
   End If
Next j: 'next residency class

'reclassify residency and create totals
 For j = 0 To 9
    If resRA(j, 0) = Lcl Then
       resclass = 1: 'local
    ElseIf resRA(j, 0) = "9" Or resRA(j, 0) = "0" Or resRA(j, 0) = "A" Then
       resclass = 3: 'non-resident
    Else
       resclass = 2: 'BC-resident
    End If


    For k = 1 To numruns
      For m = 1 To 4: 'for each parameter
        redatRA(resclass, k, m) = redatRA(resclass, k, m) + datRA(j, k, m)
        redatRA(0, k, m) = redatRA(0, k, m) + datRA(j, k, m)
      Next m
    Next k
 Next j

     'tally each parameter
     For h = 0 To 3: 'for each res class
```

```
      For k = 1 To numruns: 'for each run result
        For m = 1 To 4: 'for each parameter
          'add to res class tally
          estRA(h, m) = estRA(h, m) + redatRA(h, k, m)
        Next m
      Next k
    Next h

    'loop thru parameters & res classes, estimate means
    For k = 0 To 3: 'for each res class
      For m = 1 To 4: ' for each parameter
          estRA(k, m) = estRA(k, m) / numruns
      Next m
    Next k

    'loop thru parameters & res classes & runs, estimate variance
    For k = 0 To 3: 'for each res class, including pooled
      For m = 1 To 4: ' for each parameter
          For n = 1 To numruns
            sdRA(k, m) = sdRA(k, m) + (redatRA(k, n, m) - estRA(k, m)) ^ 2
          Next n
      Next m
    Next k

    'loop thru parameters & res classes, estimate sd
    For k = 0 To 3: 'for each res class, including pooled
      For m = 1 To 4: ' for each parameter
         sdRA(k, m) = (sdRA(k, m) / numruns) ^ 0.5
      Next m
    Next k

'write to output file code would be here

Next dataset

End Function
```

APPENDIX II. FOLLOW-UP CONTACT

Table A1.—Reported results of follow-up contact in 1978/79, all waters combined. Reproduced from Table 2, Ford and Narver 1979. Total number of steelhead licences sold in 1978/79 was 24,599.

Feature Compared	Mailings		
	1st	**Combined 1st and 2nd**	**2nd**
Questionnaires mailed (less those returned undelivered)	14,164	13,931	6,562
Total response	7,387	10,317	2,302
Percent response	52%	74%	35%
Percent of total licences sampled	30%	42%	9%
Estimated number of anglers	15,788	15,254	13,452
Estimated number of successful anglers	6,746	6,406	5,206
Estimated number of fish killed	14,700	14,190	12,268

Table A2.—Reported results of follow-up contact in 1978/79. Reproduced from Table 3, Ford and Narver 1979. Total number of steelhead licence sold in 1978/79 was 24,599. Only selected rivers' results were given in the original document.

	Estimated no. anglers			Estimated days fished		
River	**1st**	**2nd**	**1st & 2nd**	**1st**	**2nd**	**1st & 2nd**
Big Qualicum	777	564	715	3,599	1,829	3,120
Campbell	670	466	625	4,239	2,345	3,851
Cowichan	1,413	1,160	1,347	10,371	7,191	9,538
Gold	510	428	512	2,647	2,333	2,827
Nanaimo	730	554	669	6,900	4,171	5,952
Stamp	306	259	298	2,206	1,272	1,943
Englishman	481	356	449	2,529	1,893	2,328
Cheakamus	680	526	623	3,164	2,424	2,855
Fraser	751	850	760	7,751	9,451	8,097
Seymour	356	227	325	2,564	2,348	2,474
Vedder/Chilliwack	1,130	801	1,036	6,381	4,406	5,984
Squamish	1,018	871	981	4,993	3,976	4,668
Thompson	1,841	1,571	1,788	9,797	8,594	9,670
Bella Coola	884	732	852	5,375	6,717	5,668

Table A2 continued.—Reported results of follow-up contact in 1978/79.

	Estimated kill			Estimated released		
River	**1st**	**2nd**	**1st & 2nd**	**1st**	**2nd**	**1st & 2nd**
Big Qualicum	384	77	308	513	128	420
Campbell	258	37	244	534	384	518
Cowichan	921	803	890	1,060	746	968
Gold	426	263	491	490	788	684
Nanaimo	711	636	659	921	475	773
Stamp	380	137	313	539	360	475
Englishman	321	237	317	440	647	471
Cheakamus	161	85	136	342	134	278
Fraser	196	322	219	40	102	51
Seymour	111	62	95	176	239	184
Vedder/Chilliwack	62	72	62	1,164	442	997
Squamish	339	395	347	612	998	682
Thompson	1,050	1,406	1,155	466	1,353	663
Bella Coola	849	571	765	983	725	914

Table A3.—Reported results of follow-up contact in 1982/83. Only Vancouver Island (Region 1) anglers received follow-up sampling. There were 4,532 steelhead licencees in the region; of these, 2624 were sent a questionnaire.

	B	C	D	E	F	G	H
	Response	**Reported active**	**Active anglers % (C/B)**	**Estimated active anglers (AD)**	**Reported successful anglers**	**Successful anglers % (F/C)**	**Estimated successful anglers (EG)**
1st mailing	1,046	666	64	2,887	428	64	1856
2nd mailing	470	244	52	2,352	146	60	1406
Telephone survey	52	32	62	2,787	22	69	2917
Combined results	1,568	942	60.1	2,724	596		1724

Appendix III. Characteristics of Selected Steelhead Fisheries

Table A4.—Characteristics of 92 steelhead fisheries (streams) which experienced 95% of the steelhead effort in British Columbia during 1983/84 to 1995/96, as estimated by the SHA. **Reg** = BCE administrative region; **Type** refers to the composition of the fishery in terms of residency, coded as described in the report text; **Anglers** gives the estimated number of individuals who angled the stream, per year, by residency; **Angler Days** gives the estimated average annual total number of days of steelhead angling effort expended on the stream, by residency; **Anglers** gives the estimated average annual number of individuals who angled the stream, by residency; **Days Per Angler** gives the estimated average annual number of days angled per individual who angled the stream, by residency; **Streams Angled** gives the estimated average annual total number of streams angled by individuals who angled the stream, by residency. Residency classes are: **L** = (Local) resident of the same region in which the stream is located; **B** = British Columbia resident, not of the same region in which the stream is located; **N** = non-resident of British Columbia.

STREAM	Reg	Type	Anglers			Angler Days				Days Per Angler			Streams Angled		
			L	B	N	L	B	N	Total	L	B	N	L	B	N
AMOR DE COSMOS R	1	L	53.9	5.5	2.5	118	9	4	130	2.2	1.7	1.4	4.9	6.5	5.7
ASH R	1	L	41.0	3.6	1.0	122	9	2	133	3.0	2.4	1.6	3.9	4.5	7.2
BIG QUALICUM R	1	L	460.2	158.9	15.6	2629	343	62	3034	5.7	2.2	4.0	3.6	4.7	3.2
CAMPBELL R	1	L	320.2	143.9	95.0	2212	608	286	3105	6.9	4.2	3.0	4.2	4.4	2.4
CHEMAINUS R	1	L	77.8	10.5	1.0	242	25	3	270	3.1	2.4	2.9	4.7	4.7	2.9
CHINA CR	1	L	54.3	9.1	0.8	205	17	1	223	3.8	1.9	1.6	4.4	6.4	2.6
CLUXEWE R	1	L	99.7	13.2	3.8	432	32	10	474	4.3	2.4	2.7	4.6	5.1	3.7
COWICHAN R	1	L	980.2	170.7	31.2	7936	491	99	8526	8.1	2.9	3.2	2.6	4.0	2.7
ENGLISHMAN R	1	L	341.3	90.0	8.4	1999	215	32	2246	5.9	2.4	3.8	3.9	5.5	3.6
EVE R	1	L	41.8	6.0	4.2	101	10	7	118	2.4	1.6	1.8	5.4	7.9	4.9
GOLD R	1	LB	410.5	222.7	85.6	1975	687	229	2890	4.8	3.1	2.7	4.0	4.7	2.7
GOODSPEED R	1	L	27.2	4.5	0.5	171	10	1	183	6.3	2.2	2.4	4.5	6.6	4.0
HARRIS CR	1	L	116.8	9.2	1.4	418	18	2	438	3.6	2.0	1.6	3.9	4.5	4.6
HEBER R	1	L	24.0	5.2	7.5	87	9	13	109	3.6	1.8	1.8	5.6	5.6	3.9
KEOGH R	1	L	124.8	29.2	2.4	521	73	5	600	4.2	2.5	2.3	4.5	4.7	4.5
KOKISH R	1	L	37.4	4.2	1.9	129	6	9	145	3.5	1.5	4.7	4.8	4.4	4.2

Table A4 continued.—Characteristics of 92 steelhead fisheries (streams) which experienced 95% of the steelhead effort in British Columbia during 1983/84 to 1995/96, as estimated by the SHA.

			Anglers			Angler Days				Days Per Angler			Streams Angled		
STREAM	**Reg**	**Type**	**L**	**B**	**N**	**L**	**B**	**N**	**Total**	**L**	**B**	**N**	**L**	**B**	**N**
KOKSILAH R	1	L	48.7	1.3	0.3	213	6	1	219	4.4	4.4	1.8	3.6	3.4	2.0
LITTLE QUALICUM R	1	L	512.8	198.5	14.9	3374	542	49	3965	6.6	2.7	3.3	3.7	4.9	3.8
MAHATTA CR	1	L	31.4	4.5	1.2	53	8	2	62	1.7	1.7	1.3	5.0	4.4	7.0
MARBLE R	1	L	63.2	17.5	10.6	253	49	23	325	4.0	2.8	2.2	5.7	5.7	3.8
NAHMINT R	1	L	34.0	4.6	0.9	75	11	1	87	2.2	2.4	1.6	4.4	5.1	6.5
NAHWITTI R	1	L	63.0	17.1	2.0	208	34	4	246	3.3	2.0	1.8	5.4	5.3	4.9
NANAIMO R	1	L	389.2	69.7	8.5	3394	161	15	3570	8.7	2.3	1.8	3.4	4.9	3.2
NIMPKISH R	1	L	117.0	30.2	7.5	650	63	14	728	5.6	2.1	1.9	5.4	6.0	5.5
NITINAT R	1	L	56.5	8.1	1.9	137	11	4	153	2.4	1.4	2.0	4.7	7.3	3.5
OYSTER R	1	L	246.8	47.0	12.7	1178	119	29	1327	4.8	2.5	2.3	4.4	5.5	4.4
PUNTLEDGE R	1	L	99.8	15.0	2.6	685	45	4	734	6.9	3.0	1.6	4.5	5.0	4.2
QUATSE R	1	L	195.8	51.3	5.8	1476	204	23	1703	7.5	4.0	4.0	3.8	4.4	4.0
QUINSAM R	1	L	491.5	133.5	26.7	4543	475	88	5105	9.2	3.6	3.3	3.5	4.6	3.3
SALMON R	1	L	173.0	36.8	22.0	628	119	56	803	3.6	3.2	2.5	4.9	5.0	3.9
SAN JUAN R	1	L	92.8	7.5	3.5	273	10	8	291	2.9	1.3	2.4	4.0	5.0	5.3
SARITA R	1	L	44.8	5.1	1.2	117	8	1	126	2.6	1.5	1.1	4.5	4.4	4.0
SOMASS R	1	L	267.8	70.7	17.8	2294	221	50	2566	8.6	3.1	2.8	3.0	3.4	2.1
SOOKE R	1	L	73.8	4.3	0.8	321	8	4	332	4.3	1.9	4.3	3.6	5.1	2.6
SPROAT R	1	L	120.4	21.8	5.7	687	41	15	743	5.7	1.9	2.6	3.5	5.3	2.4
STAMP R	1	L	917.0	537.4	97.2	6776	1750	307	8832	7.4	3.3	3.2	3.0	3.6	2.2
WAUKWAAS CR	1	L	61.6	4.2	1.2	159	7	2	168	2.6	1.7	1.9	5.0	5.9	7.0
ALOUETTE R	2	L	572.5	7.1	0.6	5062	18	2	5082	8.8	2.6	2.9	3.3	4.0	3.3
ASHLU CR	2	L	62.2	1.5	-	165	2	0	167	2.7	1.5	-	5.9	6.4	-
CAMPBELL R	2	L	178.2	2.2	1.1	1642	7	4	1654	9.2	3.1	3.9	2.8	2.3	2.4
CAPILANO R	2	L	443.4	4.4	2.1	3160	15	8	3184	7.1	3.5	4.0	4.0	4.6	3.4
CHAPMAN CR	2	L	31.5	1.4	-	208	9	0	217	6.6	6.6	-	3.6	2.5	-

Table A4 continued.—Characteristics of 92 steelhead fisheries (streams) which experienced 95% of the steelhead effort in British Columbia during 1983/84 to 1995/96, as estimated by the SHA.

			Anglers			Angler Days				Days Per Angler			Streams Angled		
STREAM	**Reg**	**Type**	**L**	**B**	**N**	**L**	**B**	**N**	**Total**	**L**	**B**	**N**	**L**	**B**	**N**
CHEAKAMUS R	2	L	426.4	16.5	3.8	1751	60	8	1818	4.1	3.6	2.0	4.6	5.6	3.0
CHEHALIS R	2	L	1202.7	30.0	9.0	6441	68	32	6542	5.4	2.3	3.6	3.1	4.0	2.4
CHILLIWACK R	2	L	4732.0	166.6	89.7	46226	666	570	47462	9.8	4.0	6.4	2.2	2.8	1.8
COQUIHALLA R	2	L	194.9	19.0	6.0	709	42	12	763	3.6	2.2	2.0	3.7	3.9	2.2
COQUITLAM R	2	L	110.8	1.2	0.5	711	3	1	715	6.4	2.3	2.8	4.3	4.3	4.3
FRASER R	2	L	716.5	49.8	15.4	8876	315	72	9263	12.4	6.3	4.7	1.9	2.0	1.8
HARRISON R	2	L	43.0	2.2	0.5	193	10	1	203	4.5	4.3	2.0	3.9	2.8	3.0
KANAKA CR	2	L	113.6	2.6	0.2	670	7	0	677	5.9	2.7	1.0	4.6	5.3	3.0
MAMQUAM R	2	L	68.6	2.3	0.2	228	9	0	237	3.3	3.9	2.0	5.8	5.3	5.0
NAHATLATCH R	2	LB	39.3	11.0	0.5	99	26	0	125	2.5	2.4	1.0	4.4	3.2	2.0
NICOMEKL R	2	L	94.5	-	-	696	0	0	696	7.4	-	-	3.2	3.5	-
NORRISH CR	2	L	58.6	0.8	-	189	1	0	189	3.2	1.0	-	4.8	7.3	-
SEYMOUR R	2	L	531.9	14.7	2.2	3922	37	16	3974	7.4	2.5	7.0	3.9	4.3	4.2
SILVERHOPE CR	2	L	77.8	4.5	1.1	297	10	2	309	3.8	2.2	1.6	4.7	5.8	2.8
SQUAMISH R	2	L	448.5	17.5	8.8	1493	39	25	1557	3.3	2.3	2.8	4.3	5.8	3.0
STAVE R	2	L	68.3	2.4	0.5	341	5	1	346	5.0	2.1	1.3	4.3	4.3	3.3
THOMPSON R	3	BL	330.5	1200.9	231.9	2007	5347	1262	8615	6.1	4.5	5.4	1.3	2.7	1.8
ATNARKO R	5	LB	70.5	47.8	24.1	307	165	91	564	4.4	3.5	3.8	2.0	2.5	1.9
BELLA COOLA R	5	LB	211.9	144.3	75.6	1200	723	388	2311	5.7	5.0	5.1	1.6	1.8	1.4
CHILCOTIN R	5	L	117.8	43.5	7.5	411	107	21	538	3.5	2.5	2.7	1.8	2.6	2.3
CHUCKWALLA R	5	NB	1.8	13.2	27.2	11	66	85	162	5.7	5.0	3.1	2.8	2.2	1.7
DEAN R	5	NB	73.8	276.0	448.6	501	1827	2735	5063	6.8	6.6	6.1	1.7	1.9	1.2
BABINE R	6	NBL	85.2	103.2	278.2	540	541	1571	2652	6.3	5.2	5.6	2.8	2.5	1.5
BULKLEY R	6	LNB	552.1	391.0	398.0	4804	1705	1976	8485	8.7	4.4	5.0	2.1	2.5	2.0
COPPER CR	6	L	49.7	21.2	7.3	306	60	23	389	6.2	2.8	3.1	3.0	3.8	3.5
CRANBERRY R	6	BL	72.0	82.9	22.9	229	261	81	572	3.2	3.2	3.5	3.7	2.2	2.3
DEENA CR	6	LB	30.7	17.9	3.2	99	48	9	155	3.2	2.7	2.8	3.9	3.3	3.3

Table A4 continued.—Characteristics of 92 steelhead fisheries (streams) which experienced 95% of the steelhead effort in British Columbia during 1983/84 to 1995/96, as estimated by the SHA.

			Anglers			Angler Days				Days Per Angler			Streams Angled		
STREAM	**Reg**	**Type**	**L**	**B**	**N**	**L**	**B**	**N**	**Total**	**L**	**B**	**N**	**L**	**B**	**N**
HONNA R	6	L	35.4	6.5	-	143	15	0	158	4.0	2.3	-	3.1	2.7	-
ISHKHEENICKH R	6	L	45.8	10.5	3.2	156	36	7	199	3.4	3.4	2.1	4.1	2.9	4.8
KISPIOX R	6	NL	146.5	130.0	296.6	687	441	1646	2773	4.7	3.4	5.5	3.1	3.4	2.3
KITEEN R	6	L	26.8	6.8	2.7	63	13	9	85	2.3	1.9	3.5	4.2	2.3	2.9
KITIMAT R	6	L	626.0	194.2	68.8	5765	774	319	6858	9.2	4.0	4.6	2.0	2.3	2.2
KITSUMKALUM R	6	L	420.4	92.8	29.1	2937	295	110	3342	7.0	3.2	3.8	3.0	3.1	2.5
KLOIYA R	6	L	68.2	13.2	0.3	632	82	1	715	9.3	6.2	4.0	2.6	3.7	4.3
KWINAMASS R	6	L	26.8	6.4	4.1	86	21	15	122	3.2	3.3	3.7	3.3	2.3	1.5
LAKELSE R	6	L	306.3	102.5	42.2	2077	345	200	2622	6.8	3.4	4.7	3.2	3.1	2.9
MAMIN R	6	L	54.3	8.8	2.2	238	19	5	262	4.4	2.1	2.2	2.9	4.5	2.5
MEZIADIN R	6	L	27.5	6.2	3.5	103	12	13	129	3.8	2.0	3.6	3.3	3.0	2.9
MORICE R	6	LBN	255.9	218.1	160.3	1878	932	729	3538	7.3	4.3	4.5	2.0	2.2	2.2
NASS R	6	LBN	41.8	23.0	17.9	154	71	65	290	3.7	3.1	3.6	3.5	2.3	2.3
PALLANT CR	6	L	39.2	13.4	5.8	233	42	15	290	5.9	3.1	2.6	3.5	4.2	3.1
SKEENA R	6	L	713.1	372.9	327.0	6923	1772	2162	10857	9.7	4.8	6.6	2.3	1.9	1.7
SUSKWA R	6	LN	29.7	18.2	20.2	126	39	46	211	4.2	2.2	2.3	3.7	4.2	4.1
SUSTUT R	6	NB	11.7	46.2	64.2	68	165	366	600	5.9	3.6	5.7	3.8	1.4	1.4
TAHLTAN R	6	L	32.2	7.2	5.3	120	19	15	154	3.7	2.6	2.8	1.6	1.7	1.5
TLELL R	6	L	82.7	19.1	4.4	387	45	8	440	4.7	2.4	1.7	2.6	3.1	3.3
TSEAX R	6	L	75.9	26.0	15.4	247	69	45	361	3.3	2.7	2.9	4.3	3.2	3.1
YAKOUN R	6	L	314.5	112.6	21.5	2129	388	84	2601	6.8	3.4	3.9	2.1	2.6	2.1
ZYMOETZ R	6	L	263.4	100.2	73.5	1550	294	302	2146	5.9	2.9	4.1	3.4	3.5	2.9

Appendix IV. Field Survey Details

Table A5.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Atnarko & Bella Coola	76/77	Daily checks 1-Nov-76 to 31-Jan-77; two weekdays and both weekend days each week during Feb and most of Mar, daily checks from late Mar through May. Results traverse licence year bound but could be partitioned.	Chinook anglers not separated from steelhead anglers. Subjective upward adjustment of 10% for Apr and 30% for May.	Wilkinson 1978a
Atnarko & Bella Coola	77/78	15-Oct to 5-Dec-77 and 23-Mar to 31-May-78, daily checks. Results traverse licence year break, but could be partitioned.	May chinook anglers not separated from steelhead anglers. Subjective upward adjustment of 10% for Apr 1 to 15, 15% for Apr 16 to 30, and 30% for May. Total of 3355 days directly censused.	Wilkinson 1978b
Babine	76/77	Unknown	Unknown	Narver 1978
Big Qualicum	76/77	1-Dec-76 to 30-Apr-77. Unclear if full season coverage.	447 respondents; did not enumerate all anglers so cannot extrapolate to total.	Hooton and Lewynsky 1985
Big Qualicum	77/78	1-Dec-76 to 30-Apr-77. Unclear if full season coverage.	Survey methodology described in report (Hooton 1977) not available ATP. Count of all observed angler days was 2856.	Hooton and Lewynsky 1985
Big Qualicum	78/79	1-Dec-78 to 30-Apr-79. Unclear if full season coverage. Results traverse licence year bound but could be partitioned.	Survey methodology described in report (Hooton 1977) not available ATP. Count of all observed angler days was 2990. Response 80%. Extrapolation of hours, kill and release not made.	Hooton and Lewynsky 1985

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Big Qualicum	79/80	1-Dec-79 to 30-Apr-80. Unclear if full season coverage. Results traverse licence year bound but could be partitioned.	Survey methodology described in Hooton (1977)not available ATP. Count of all observed angler days was 1974; response 70%. Extrapolation of hours, kill and release not made.	Hooton and Lewynsky 1985
Big Qualicum	80/81	1-Dec-80 to 30-Apr-81. Unclear if full season coverage.	Survey methodology described in Hooton (1977) not available ATP. Total of 203 respondents, no count of other observed angler days so cannot extrapolate to complete estimate.	Hooton and Lewynsky 1985
Bulkley	69/70	Oct and Nov 69. Total of 12 days checked.		Pinsent 1970
Bulkley	74/75		Mainly an opinion survey.	Remington 1974
Bulkley	82/83	Temporal coverage undocumented. Weekday/weekend stratification.	Skeena confluence to Mile 3 on Morice River by jet boat. 701 angler days actually checked. This year's study is poorly documented in the report. No attempt to extrapolate to total catch.	O'Neill and Whately 1984
Bulkley	83/84	26-Aug-83 to 20-Nov-83. Weekday/weekend stratification.	Chicken Creek to Mile 3 on Morice River by jet boat, exclusive of Quick to Walcott. 2676 angler-days checked. Unclear how final totals were calculated.	O'Neill and Whately 1984
Bulkley	89/90	1-Sep to 31-Oct-89.		Lewynsky and Olmsted 1990
Campbell	75/76	1-Dec-75 to 18-Apr-76. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 14 days per month, with 2 or 3 randomly-selected periods sampled on each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Campbell	76/77	17-Nov-76 to 31-Mar-77. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 20 days per month, 4 periods between 08:00 and 17:00 on each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Campbell	77/78	15-Nov-77 to 31-Mar-78. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 20 days per month, 4 periods between 08:00 and 17:00 on each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Campbell	78/79	17-Nov-78 to 31-Mar-79. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 20 days per month, 4 periods between 08:00 and 17:00 on each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Campbell	79/80	15-Nov-79 to 31-Mar-80. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 16 days per month, 4 periods between 08:00 and 17:00 on each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Chilko & Chilcotin	72/73	Fall and spring, 5 to 8 randomly selected days per month; weekend/weekday strata.	Between TH Ranch and the Chilko-Taseko junction.	Spence 1978
Chilko & Chilcotin	73/74	Spring only, 5 to 8 randomly selected days per month; weekend/weekday strata.	Between TH Ranch and the Chilko-Taseko junction.	Spence 1978

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Chilko & Chilcotin	75/76	Spring only, 5 to 8 randomly selected days per month. Weekend/weekday strata.	Between TH Ranch and the Chilko-Taseko junction.	Spence 1978
Chilko & Chilcotin	76/77	Fall and spring; 5 to 8 randomly selected days per month in Mar and 5 days per week in Apr; weekend/weekday strata.	Between TH Ranch and the Chilko-Taseko junction.	Spence 1978
Chilko & Chilcotin	77/78	3-Oct to 17-Nov-77; weekend/weekday strata.	Between TH Ranch and the Chilko-Taseko junction.	Spence 1978
Chilko & Chilcotin	78/79	7-Oct to 12-Nov-78 (rivers closed 31 Dec); twice-daily coverage of Chilcotin; Chilko every second day.	Entire Chilcotin; between mouth and Siwash Bridge on the Chilko. Reconciled logbooks with on-site activity checks.	Bell 1979
Chilko & Chilcotin	79/80	6-Oct to 12-Nov-79 with spot checks until 24-Nov; closed 31-Dec. Weekend coverage on Chilko; twice-daily coverage on the Chilcotin.	Chilko from its mouth to Chilko-Taseko junction; Chilcotin between Hanceville Bridge and the mouth of the Chilko. Reconciled logbooks with on-site checks.	Bell 1980
Chilko & Chilcotin	80/81	4-Oct to 15-Nov-80, cursory checks until 22-Nov; river closed 31-Dec. Once or twice-daily coverage 3 weekdays and 2 weekend days per week on Chilcotin, weekend coverage on Chilko.	Chilko from its mouth to Chilko-Taseko junction; Chilcotin between Hanceville Bridge and the mouth of the Chilko. Reconciled logbooks with on-site activity checks.	Bell 1981
Chilko & Chilcotin	81/82	4-Oct to 6-Dec-81, river closed 31-Dec. Once or twice-daily coverage 3 weekdays and 2 weekend days per week; Chilko weekend coverage only during same period.	Chilko from its mouth to Chilko-Taseko junction; Chilcotin between Hanceville Bridge and the mouth of the Chilko. Reconciled logbooks with on-site activity checks.	Bell and Kirsebom 1982
Chilko & Chilcotin	82/83	9-Oct to 27-Nov-82 (river closed 31-Dec). Once or twice-daily coverage 3 weekdays and 2 weekend days per week.	Reconciled logbooks with on-site activity checks.	Evans 1983a

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Lic Yr	Temporal details	Spatial and other survey details	Reference
Chilko & Chilcotin	83/84	6-Oct to 4-Dec-83, on 'a few randomly selected' weekdays, one or two weekend days per week (river closed 31-Dec).		Evans and Van Dyk 1984
Chilko & Chilcotin	84/85	10-Oct to 28-Nov-84, on 'a few randomly selected' weekdays and one or two weekend days per week (river closed 31-Dec).		Evans and Van Dyk 1985
Chilliwack	83/84	7-Jan to 23-Apr-84. Strata were season (day length), time of day (AM/PM). Extrapolated to extend period to 1-Jan to 30-Apr, but do not include December (est. ~10%). Results do not allow partitioning across licence year break.	Difficult to evaluate other biases in design.	Clark and Facchin 1986
Chilliwack	84/85	1-Dec-84 to 30-Apr-85. Fishery likely began in November. Strata were seasonal (day length) and time of day. Results would allow partitioning across licence year break.	About 1/4 of anglers during December claimed species other than ST as target.	Scott and Lewynsky 1985
Clore	78/79	1-Sep to 29-Oct-78, fishery well underway in Aug and terminated about 1-Nov due to heavy rains.		Chudyk and Whately 1980
Clore	79/80	18-Aug to 13-Dec-79; fishery likely continued until Clore closed on 15-Jan.		Chudyk and Whately 1980
Coquitlam	76/77	Unknown	Unknown	Narver 1978
Dean	71/72	12-Jul to 19-Sep-71.	Estimated 90% efficiency. No data for James' guide camp or loggers.	Leggett and Prediger 1972
Dean	72/73	15-Jun to 9-Sep-72.	Data exclude loggers.	George and Leggett 1982

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Dean	73/74	1-Jun to 24-Sep & 24-Oct to 5-Nov-73; angling likely terminated on ~ 5-Nov.	Data include loggers.	Hemus 1974
Dean	74/75	2-Jun to 15-Sep-74.	Est efficiency 95%. Data exclude loggers.	Leggett and Westover 1976
Dean	75/76	1-Jun5 to 20-Sep-75.	Data exclude loggers.	Leggett and Narver 1976
Dean	76/77	2-June to 7-Sep-76.	Data exclude loggers. Est efficiency 95%	Leggett et al. 1977
Dean	77/78	2-Jun to 30-Sep-77.	Data exclude loggers. Est efficiency 95%	Leggett et al. 1978
Dean	78/79	1-Jun to 24-Sep-78.	Data exclude loggers.	Bell and Leggett 1979
Dean	79/80	1-Jun to 24-Sep-79.	No data for Upper Dean Lodge or loggers.	Dolighan 1981
Dean	80/81	1-Jun to 21-Sep-80.	No data for Upper Dean Lodge or loggers.	George 1981; George and Leggett 1982
Dean	81/82	1-Jun to 23-Sep-81.	Data exclude loggers.	George 1982; George and Leggett 1982
Dean	82/83	1-Jun to 26-Sep-82.		Evans 1983b
Dean	83/84	1-Jun to 12-Jul-83; terminated early.		Evans 1984
Dean	84/85	1-Jun to early/mid Sep-84.		Wilders 1995
Dean	85/86	1-Jun to early/mid Sep-85.		Wilders 1995
Dean	86/87	1-Jun to early/mid Sep-86.		Wilders 1995
Dean	87/88	1-Jun to early/mid Sep-87.		Wilders 1995
Dean	88/89	1-Jun to early/mid Sep-88.	Applied % retained from digital database to Wilders' total catch figure, for retained.	Wilders 1995
Dean	89/90	1-Jun to early/mid Sep-89.	Applied % retained from digital data.	Wilders 1995
Dean	90/91	1-Jun to early/mid Sep-90.		Wilders 1995

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Dean	91/92	1-Jun to early/mid Sep-91.		Wilders 1995
Dean	92/93	1-Jun to early/mid Sep-92.		Wilders 1995
Dean	93/94	1-Jun to early/mid Sep-93.		Wilders 1995
Dean	94/95	1-Jun to early/mid Sep-94.		Wilders 1995
Dean	95/96	1-Jun to early/mid Sep-95.		Anonymous 1998
Dean	96/97	1-Jun to early/mid Sep-96.		Anonymous 1998
Gold & Gold	75/76	1-Dec-75 to 30-Jun-76; total of 68 days chosen at random: 10 per month, of which at least four were weekend days.	Windshield survey. Not possible to accurately partition between 75/76 and 76/77. No matching data in previous or subsequent year.	Hooton 1976
Keogh	75/76	Unknown	Unknown	Narver 1978
Keogh	76/77	Unknown	Unknown	Narver 1978
Keogh	77/78	Unknown	Unknown	Narver 1978
Kispiox	69/70	Oct and Nov 69. 12 days checked in total.		Pinsent 1970
Kispiox	75/76	Terminated end of Oct-75, fishery effectively terminated end of first week of Nov; angling closure from 1-Mar to 31-May.	Total number of anglers "an educated guess only but considered to be within +/-10%"; method of extrapolation not documented. Censused 219 anglers who retained 114 and released 389.	Whately 1977
Kispiox	89/90	1-Sep to 31-Oct-89.	Skeena confluence to Cullen confluence.	Lewynsky and Olmsted 1990
Kispiox	96/97	15-Sep to 31-Oct-96; fishery initiated in early Sep or earlier, and likely continued sporadically into Nov.	Sweetin confluence to Kispiox village. Does not provide an estimate of angler days.	Tallman 1997

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Kitimat	77/78		Casual survey, not intended to quantify all effort and catch. Effort not total but daily to time of interview, recorded in hours, so CPE is estimable only per hour	Eccles et al. 1977
Little Campbell	77/78	Unknown	Unknown	Narver 1978
Morice	69/70	Oct / Nov 69. Total of 10 days checked.		Pinsent 1970
Morice	76/77	4-Sep to 13-Dec-76; fishery initiated in late Aug and closed by regulation 15-Jan.	Included 4 miles of the Bulkley, from Morice confluence to Barrett Station. Second vehicle entry/exit point vie Owen Lakes, which was monitored only on holiday weekends.	Morris et al. 1977
Morice	77/78	15-Aug to 30-Nov-77; fishery initiated in late Aug, closed by regulation 15-Jan.	Included 4 miles of the Bulkley, from Morice confluence to Barrett Station. There is another vehicle entry/exit point vie Owen Lakes, which was monitored on holiday weekends.	Whately et al. 1978
Nicomekl	77/78	Unknown	Unknown	Narver 1978
Quinsam	75/76	1-Dec-75 to 18-Apr-76. Did not cover entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 14 days per month, 2 or 3 randomly-selected periods each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Quinsam	76/77	17-Nov-76 to 31-Mar-77. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 20 days per month, 4 periods between 8:00 & 17:00 each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986

Table A5. continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Quinsam	77/78	15-Nov-77 to 31-Mar-78. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 20 days per month, 4 periods between 8:00 & 17:00 each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Quinsam	78/79	17-Nov-78 to 31-Mar-79. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 20 days per month, 4 periods between 8:00 & 17:00 each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Quinsam	79/80	15-Nov-79 to 31-Mar-80. Did not cover the entire season. Season stratified into 10 periods. Day stratified into 2-hr periods; sampled 16 days per month, 4 periods between 8:00 & 17:00 each day.	Assumption of angler day as 2 hr based on subsampling, unknown validity.	Carswell et al. 1986
Salmon	77/78	Unknown	Unknown	Narver 1978
Serpentine	77/78	Unknown	Unknown	Narver 1978
Skeena	89/90	1-Aug to 15-Oct-89.	Zymoetz confluence to Kasiks confluence. Cannot distinguish salmon and steelhead anglers	Lewynsky and Olmsted 1990
South Alouette	76/77	Unknown	Unknown	Narver 1978
Squamish	77/78	Unknown	Unknown	Narver 1978
Suskwa	69/70	Oct / Nov 69. Total of 5 days checked.		Pinsent 1970
Thompson	76/77	1-Oct-76 to 31-Mar-77. .Fishery may start before 1-Oct.	Difficult to evaluate methods of expansion of sample to total effort and catch. Est 80% sampling efficiency. Unknown effort occurs u/s of Lytton to Martel sampled area.	Antifeau 1977

Table A5. continued. —Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Thompson	77/78	Oct-77 through Mar-78. Fishery may start before 1-Oct.	Unknown effort occurs u/s of Lytton to Martel sampled area. Checked 2943 angler days.	Dolighan 1978
Thompson	78/79	Oct-78 through Mar-79. Fishery may start before 1-Oct.	Methodology unclear. Unknown effort occurs u/s of the Lytton to Martel sampled area.	Dolighan 1979
Thompson	80/81	Oct through Dec-80 (river closed 1-Jan to 31-May). Fishery may start before 1-Oct.	Unknown method of interpolation. Unknown effort occurs u/s of Lytton to Martel sampled area. Checked 1996 angler days' catch was only 239 fish (much lower success rate than claimed for all days).	Caverly 1981
Thompson	81/82	28-Sep through Dec-81, entire river.	2 persons checking the river most days. Checked 3632 angler days (56% of total), remainder reported as days fished since last check. Number of sample days unrecorded.	Caverly 1982
Thompson	82/83	26-Sep through 28-Nov-82, entire river, weekends only for much of the period.	Unexplained discrepancy between 3905 and 4507 as total angler days.	Moore 1983
Thompson	83/84	26-Sep through 31-Dec-83.	Number of sample days unrecorded. Report very brief, discrepancy between two figures for total angler days (6362 and 6971) is unexplained.	Moore 1984
Thompson	84/85	1-Oct to 31-Dec-84; sampled 79 days of 92 calendar days during the period.		Moore and Olmsted 1985
Zymoetz	78/79	1-Sep to 29-Oct-78; fishery well underway in August and terminated about 1-Nov due to heavy rains.		Chudyk and Whately 1980

Table A5 continued.—Additional detail from steelhead angler survey reports. **Year** gives the licence year of the survey.

Water	Year	Temporal details	Spatial and other survey details	Reference
Zymoetz	79/80	18-Aug to 13-Dec-79; fishery continued through winter due to warm dry conditions --- whether spring closure was in place is unknown.		Chudyk and Whately 1980
Zymoetz & Clore	89/90	15-Aug to 15-Oct-89.	Skeena confluence to Clore confluence, and including Clore River.	Lewynsky and Olmsted 1990

Table A6.—Additional detail about residency-stratified data from steelhead angler survey reports. **Year** gives the licence year of the survey. Report references are provided in Table A5.

Water	Year	Residency details
Dean River	71/72	Categories: resident and non-resident (assumed Provincial but may be Canadian); Angler days appear to exclude one guide camp (James) and loggers
Chilko & Chilcotin Rivers	72/73	Categories: local residents (Region 5); other BC; non-residents
Dean River	72/73	Categories: BC, Canadian and non-resident alien
Chilko & Chilcotin Rivers	73/74	Categories: local residents (Region 5); other BC; non-residents
Dean River	73/74	Categories: BC, Canadian and non-resident alien
Dean River	74/75	Categories: BC, Canadian and non-resident alien
Dean River	75/76	Angler days and catch not categorized by residency
Kispiox River	75/76	Categories as per SHA
Chilko & Chilcotin Rivers	76/77	Categories: local residents (Region 5); other BC; non-residents
Morice River	76/77	Catch, effort summarized by non-corresponding criteria: western Region 6 anglers considered non-local

Table A6 continued.—Additional detail about residency-stratified data from steelhead angler survey reports.

Water	Year	Residency details
Thompson River	76/77	Categories: local residents --- considered those residing "along the Thompson R" so cannot compare to SHA local category (region 3); other BC; other Canada; and USA. Kill/release not broken down by residency.
Atnarko & Bella Coola Rivers	77/78	Categories : "Valley residents", other BC, non-residents of BC; 792 Angler days of unknown residency
Chilko & Chilcotin Rivers	77/78	Categories: local residents (Region 5); other BC; non-residents
Morice River	77/78	Catch, effort summarized by non-corresponding criteria: western Region 6 anglers considered non-local
Thompson River	77/78	Categories: BC, Canada and USA
Chilko & Chilcotin Rivers	78/79	Categories: local residents (Region 5); other BC; non-residents
Clore River	78/79	Categorized anglers by SHA residence, but summarized Angler days and catch by non-corresponding criteria (local = Terrace, PR and Kitimat only) which necessitated recalculation
Thompson River	78/79	Categories: local residents --- considered "those residing within 100 km of Thompson R" so cannot compare to SHA local category (region 3); other BC; other Canada; and USA.
Zymoetz River	78/79	Categorized anglers by SHA residence, but summarized Angler days and catch by non-corresponding criteria (local = Terrace, PR and Kitimat only) which necessitated recalculation
Chilko & Chilcotin Rivers	79/80	Categories: local residents (Region 5); other BC; non-residents
Clore River	79/80	Categorized anglers by SHA residence, but summarized Angler days and catch by non-corresponding criteria (local = Terrace, PR and Kitimat only) which necessitated recalculation
Zymoetz River	79/80	Categorized anglers by SHA residence, but summarized Angler days and catch by non-corresponding criteria (local = Terrace, PR and Kitimat only) which necessitated recalculation
Chilko & Chilcotin Rivers	80/81	Categories: local residents (Region 5); other BC; non-residents
Thompson River	80/81	Categories: local residents --- considered "those residing within 100 km of Thompson R" so cannot compare to SHA local category (region 3); other BC; other Canada; and USA.
Chilko & Chilcotin Rivers	81/82	Categories: local residents (Region 5); other BC; non-residents

Table A6 continued.—Additional detail about residency-stratified data from steelhead angler survey reports.

Water	Year	Residency details
Thompson River	81/82	Categories: local residents --- considered "those residing within 100 km of Thompson R" so cannot compare to SHA local category (region 3); other BC; other Canada; and USA.
Chilko & Chilcotin Rivers	82/83	Categories: local residents (Region 5); other BC; non-residents
Thompson River	82/83	Categories: local residents --- considered "those residing within 100 km of Thompson R" so cannot compare to SHA local category (region 3); other BC; other Canada; and USA.
Bulkley River	83/84	Within-BC residence areas do not correspond to SHA categories
Chilko & Chilcotin Rivers	83/84	Categories: local residents (Region 5); other BC; non-residents
Thompson River	83/84	Categories: local residents --- considered "those residing within 100 km of Thompson R" so cannot compare to SHA local category (region 3); other BC; other Canada; and USA.
Chilko & Chilcotin Rivers	84/85	Categories: local residents (Region 5); other BC; non-residents
Thompson River	84/85	Categories: local -- MOE Region 3 residents south of and including Kamloops so not comparable to Region 3 SHA result; other BC; other Can; US; other NR
Dean River	87/88	Categories: BC, Canadian and non-resident alien
Dean River	88/89	Categories: BC, Canadian and non-resident alien
Dean River	89/90	Categories: BC, Canadian and non-resident alien
Dean River	90/91	Categories: BC, Canadian and non-resident alien
Dean River	91/92	Categories: BC, Canadian and non-resident alien
Dean River	92/93	Categories: BC, Canadian and non-resident alien
Dean River	93/94	Categories: BC, Canadian and non-resident alien
Dean River	94/95	Categories: BC, Canadian and non-resident alien
Dean River	95/96	Categories: BC, Canadian and non-resident alien
Dean River	96/97	Categories: BC, Canadian and non-resident alien

Appendix V. Comparable Field and SHA Estimates

Table A7.—Unadjusted data available for comparison of **SHA** estimates to **Field** angler survey estimates. **River** : name of river or river-pair; **Year** : licence year; **Type** : steelhead population type, where W = Winter-run, S = Summer-run, WS = both types; **Kill** = total number of steelhead retained; **Rel** : total number of steelhead released; **Tech** : techniques utilized in the field survey -- each letter corresponds to a single technique as coded in **Table 2**; **Add Bias** : additional biases (above and beyond those associated with the utilized techniques) associated with the field survey where each letter corresponds to a single bias as coded in Table 1; **CAdj** : upward adjustment factor for catch recommended in the survey report; **EAdj** : upward adjustment factor for effort recommended in the survey report. ‡ indicates field survey data were excluded from analyses due to incompleteness or unsuitability.

			SHA				Field								
River	**Year**	**Type**	**Anglers**	**Days**	**Kill**	**Rel**	**Anglers**	**Days**	**Total Catch**	**Kill**	**Rel**	**Tech**	**Add Bias**	**CAdj**	**EAdj**
Atnarko & Bella Coola	77/78	WS	228 & 871	6773	1177	1149	NA	3614	NA	NA	NA	RFGIE	TDY		
Chilko & Chilcotin	72/73	S	215 & 613	3329	967	322	NA	999	NA	110	NA	RT	ST		
Chilko & Chilcotin ‡	73/74	S	143 & 483	2679	504	180	NA	653	NA	58	NA	RT	ST		
Chilko & Chilcotin	75/76	S	236 & 560	3902	884	259	NA	957	NA	149	NA	RT	ST		
Chilko & Chilcotin	76/77	S	234 & 796	4325	665	96	NA	1202	NA	55	NA	RT	ST		
Chilko & Chilcotin	77/78	S	101 & 528	2236	255	157	NA	368	NA	161	NA	RT	ST		
Chilko & Chilcotin	78/79	S	19 & 148	527	37	76	92	232	25	18	7	RILF	ST		
Chilko & Chilcotin	79/80	S	53 & 184	651	85	166	104	316	85	50	35	RILF	ST		
Chilko & Chilcotin	80/81	S	16 & 110	739	33	142	98	362	77	27	50	RILF	ST		
Chilko & Chilcotin	81/82	S	36 & 157	549	40	48	130	331	108	36	72	RILF	ST		
Chilko & Chilcotin	82/83	S	159	582	71	165	118	289	135	50	85	RILF	ST		
Chilko & Chilcotin	83/84	S	215	690	77	87	135	353	121	40	81	RILF	ST		
Chilko & Chilcotin	84/85	S	233	594	92	217	92	217	83	34	49	RILF	ST		
Zymoetz & Clore	89/90	S	441	1807	52	1440	NA	749	279	0	279	XT	T		
Gold [1]	75/76	WS	846	5009	991	1084	NA	3255	2056	867	1189	VTC	YL		
Babine	76/77	S	275	1185	157	977	NA	800	NA	84	NA	U	U		
Big Qualicum	76/77	W	414	1656	253	520	NA	NA	NA	NA	NA	VTC	AT		

Table A7 continued.—Data available for comparison of **SHA** estimates to **Field** angler survey estimates. All residency classes pooled.

			SHA				Field								
River	**Year**	**Type**	**Anglers**	**Days**	**Kill**	**Rel**	**Anglers**	**Days**	**Total Catch**	**Kill**	**Rel**	**Tech**	**Add Bias**	**CAdj**	**EAdj**
Big Qualicum	77/78	W	661	4085	786	1814	NA	2856	1437	744	693	VTC	AT		
Big Qualicum	78/79	W	777	3599	384	513	NA	2990	NA	NA	NA	VTC	AT		
Big Qualicum	79/80	W	394	2005	206	866	NA	1974	NA	NA	NA	VTC	AT		
Big Qualicum	80/81	W	390	3082	327	2246	NA	NA	NA	NA	NA	VTC	AT		
Bulkley	69/70	S	1128	4490	1244	0	NA	369	NA	220	NA	RB	DST		
Bulkley	82/83	S	1451	10816	1385	3269	NA	3794	NA	116	NA	RIT	S+		
Bulkley	83/84	S	1457	10349	1091	3455	476	4304	1309	280	1029	RIT	S		
Bulkley	89/90	S	1311	7977	55	5488	NA	4105	3067	0	3067	HST	ST		
Bulkley	97/98						NA	4317	5497	0	5497				
Bulkley	98/99						NA	6116	8956	0	8956				
Campbell	75/76	W	777	4640	598	666	NA	4376	498	326	172	RT	DT		
Campbell	76/77	W	734	4468	284	452	NA	4592	379	227	152	RT	DT		
Campbell	77/78	W	620	3900	264	544	NA	2819	283	163	120	RT	DT		
Campbell	78/79	W	670	4239	258	534	NA	4478	336	175	161	RT	DT		
Campbell	79/80	W	575	3383	246	642	NA	3014	350	120	230	RT	DT		
Chilliwack	83/84	W	2007	16811	855	8656	NA	11798	4960	393	4567	STCR	T		
Chilliwack	84/85	W	3744	33877	2302	23270	NA	19749	11311	1434	9877	STCR	T		
Clore	78/79	S	24	231	15	73	60	117	37	17	20	XRIF	T		
Clore	79/80	S	61	141	32	62	117	184	49	18	31	XRIF	T		
Coquitlam	76/77	W	266	1694	56	37	NA	390	NA	69	NA	U	U		
Dean	71/72	S	389	1780	1288	2677	364	1041	2231	629	1602	RGF	T	0.11	0.11
Dean	72/73	S	456	2627	1452	2940	NA	1296	1661	631	1030	RGF	T		
Dean	73/74	S	626	3600	1316	4597	NA	1994	2810	937	1873	RGF	T		
Dean	74/75	S	712	3453	1132	2604	NA	2338	1827	529	1298	RGF	T	0.05	0.05
Dean	75/76	S	793	3579	1156	3320	614	2636	2012	785	1227	RGF	T		

Table A7 continued.—Data available for comparison of **SHA** estimates to **Field** angler survey estimates. All residency classes pooled.

			SHA				Field								
River	Year	Type	Anglers	Days	Kill	Rel	Anglers	Days	Total Catch	Kill	Rel	Tech	Add Bias	CAdj	EAdj
Dean	76/77	S	754	3263	727	1646	636	2841	972	399	573	RGF	T	0.05	0.05
Dean	77/78	S	677	3419	623	2628	661	3025	1832	495	1337	RGF	T	0.05	0.05
Dean	78/79	S	718	4204	617	2626	NA	3305	1478	391	1087	RGF	T		
Dean	79/80	S	567	3129	262	2369	NA	2825	1311	229	1082	RGF	T		
Dean	80/81	S	670	4226	495	3652	538	2779	2285	381	1904	RGF	T		
Dean	81/82	S	722	4762	346	4680	614	3263	2035	251	1784	RGF	T		
Dean	82/83	S	660	3664	475	5023	NA	2996	3132	343	2789	RGF	T		
Dean	84/85	S	652	3727	470	7457	NA	3278	NA	5347	NA	RGF	T		
Dean	85/86	S	757	4580	547	8221	NA	4102	NA	5368	NA	RGF	T		
Dean	86/87	S	946	5264	530	7249	NA	5057	NA	4768	NA	RGF	T		
Dean	87/88	S	994	5886	372	9134	NA	4218	NA	4848	NA	RGF	T		
Dean	88/89	S	985	5858	258	6679	623	5005	4150	200	3950	RGF	T		
Dean	89/90	S	949	6247	232	8181	571	5052	4700	175	4525	RGF	T		
Dean	90/91	S	870	5462	3	5675	615	4156	3200	0	3200	RGF	T		
Dean	91/92	S	720	4554	12	5290	595	3846	2733	0	2733	RGF	T		
Dean	92/93	S	755	6023	13	6157	560	3613	3026	0	3026	RGF	T		
Dean	93/94	S	768	4788	9	4907	651	4494	3063	0	3063	RGF	T		
Dean	94/95	S	616	4234	0	4623	595	4076	3280	0	3280	RGF	T		
Dean	95/96	S	626	4851	15	5029	586	3826	3674	0	3674	RGF	T		
Dean	96/97	S	649	4961	0	7210	576	3983	4391	0	4391	RGF	T		
Keogh	75/76	W	198	692	77	118	NA	550	NA	70	NA	U	U		
Keogh	76/77	W	126	537	40	65	NA	540	NA	36	NA	U	U		
Keogh	77/78	W	104	386	29	157	NA	206	NA	31	NA	U	U		
Kispiox	69/70	S	1319	5349	772	0	NA	1363	NA	362	NA	RB	DST		
Kispiox	75/76	S	848	4396	247	887	450	4137	1035	234	801	REV	TD		

Table A7 continued.—Data available for comparison of **SHA** estimates to **Field** angler survey estimates. All residency classes pooled.

			SHA				Field								
River	**Year**	**Type**	**Anglers**	**Days**	**Kill**	**Rel**	**Anglers**	**Days**	**Total Catch**	**Kill**	**Rel**	**Tech**	**Add Bias**	**CAdj**	**EAdj**
Kispiox	89/90	S	785	3994	4	2122	NA	3605	1384	0	1384	HST	ST		
Kispiox	96/97	S	615	2705	9	1852	NA	NA	637	0	637	RST	T		
Little Campbell	77/78	W	186	1739	186	120	NA	557	NA	183	NA	U	U		
Morice	69/70	S	1136	4997	1464	0	NA	645	NA	175	NA	RB	DST		
Morice	76/77	S	764	3087	553	595	NA	1971	394	279	115	XRF	TS+		
Morice	77/78	S	892	3836	630	952	769	1833	627	416	211	XRIF	TS+		
Nicomekl	77/78	W	120	694	79	24	NA	241	NA	43	NA	U	U		
Quinsam	75/76	W	433	1545	240	416	NA	834	104	54	50	RT	DT		
Quinsam	76/77	W	460	2178	158	272	NA	1219	174	105	69	RT	DT		
Quinsam	77/78	W	380	1907	163	446	NA	1164	165	86	79	RT	DT		
Quinsam	78/79	W	347	1584	76	391	NA	1956	240	103	137	RT	DT		
Quinsam	79/80	W	441	2789	204	954	NA	2512	430	130	300	RT	DT		
Salmon	77/78	W	242	852	121	213	NA	188	NA	67	NA	NA	NA		
Serpentine	77/78	W	34	144	3	0	NA	152	NA	17	NA	U	U		
Skeena ‡	89/90	S	1962	15242	643	2190	NA	16683	568	210	358	HST	D		
South Alouette	76/77	W	368	1972	63	22	NA	366	NA	41	NA	U	U		
Squamish[1]	77/78	W	NA	8830	501	NA	NA	5572	NA	396	NA	U	U		
Suskwa	69/70	S	116	300	146	0	NA	425	NA	91	NA	RB	DST		
Thompson	76/77	S	2011	11038	1127	287	NA	5073	733	694	39	RFC	ST	0.25	
Thompson	77/78	S	2078	10391	1345	798	NA	5016	1110	924	186	RFC	ST		
Thompson	78/79	S	1841	9797	1050	466	1207	5059	949	779	170	RFI	ST		
Thompson	80/81	S	1904	10449	1170	1475	1078	3517	843	580	263	RFI	STD	0.20	
Thompson	81/82	S	2351	13232	1698	2166	1539	6492	1342	780	562	RFI	ST		

[1] Squamish SHA totals for 1977/78 are given as reported in Narver (1978), and do not coincide with digital database totals.

Table A7 continued.—Data available for comparison of **SHA** estimates to **Field** angler survey estimates. All residency classes pooled.

			SHA				Field								
River	**Year**	**Type**	**Anglers**	**Days**	**Kill**	**Rel**	**Anglers**	**Days**	**Total Catch**	**Kill**	**Rel**	**Tech**	**Add Bias**	**CAdj**	**EAdj**
Thompson	82/83	S	2249	12176	1826	2325	1453	6310	1355	795	560	RFI	DT	0.40	0.40
Thompson	83/84	S	2228	12308	1482	1989	1560	6971	1130	717	413	RFI	DT		
Thompson	84/85	S	2620	13395	2335	5065	2356	10490	4155	1289	2866	RFI	T	0.20	0.20
Zymoetz	78/79	S	605	3104	378	588	590	1093	227	117	110	XRIF	T		
Zymoetz	79/80	S	511	2302	262	250	424	874	127	78	49	XRIF	T		

APPENDIX VI. RESIDENCY-SPECIFIC COMPARABLE FIELD AND SHA ESTIMATES

Table A8.—Data available for comparison of the estimated number of participating anglers, stratified by residency, from **Field** studies and the **SHA**. **Local** = anglers resident in the BCE region enclosing the stream; **other BC** = BC anglers residing in a region other than that containing the stream; **all BC** = all BC anglers; **NR** = non-residents of BC. NA = value not estimable from available results. The # symbol indicates that field and SHA values are not strictly comparable, usually due to varying residency definitions by field studies.

		SHA				Field				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Dean River	75/76	128	345	473	320	NA	NA	325	289	0
Kispiox River	75/76	218	324	542	306	50	113	163	287	0
Morice River	77/78	211	540	751	141	229	427	656	113	0
Clore River	78/79	16	6	22	2	44	8	52	8	0
Zymoetz River	78/79	317	205	522	83	359	146	505	85	0
Clore River	79/80	39	13	52	9	88	8	96	21	0
Zymoetz River	79/80	276	182	458	57	311	72	383	41	0
Bulkley River	83/84	669	534	1203	254	NA	NA	395	81	0
Thompson River	84/85	625	1783	2408	212	351	1416	1767	192	0
Dean River	90/91	54	314	368	502	NA	NA	256	359	0
Dean River	91/92	41	241	282	438	NA	NA	228	367	0
Dean River	92/93	52	289	341	414	NA	NA	228	332	0
Dean River	93/94	55	241	296	472	NA	NA	250	401	0
Dean River	94/95	64	167	231	385	NA	NA	176	419	0
Dean River	96/97					NA	NA	156	430	0

Table A9.—Data available for comparison of the estimated number of angler days, stratified by residency, from **Field** studies and the **SHA**. **Local** = anglers resident in the BCE region enclosing the stream; **other BC** = BC anglers residing in a region other than that containing the stream; **all BC** = all BC anglers; **NR** = non-residents of BC. NA = value not estimable from available results. The # symbol indicates that field and SHA values are not strictly comparable, usually due to varying residency definitions by field studies.

		SHA				Field				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Dean River	71/72	NA	NA	NA	NA	NA	NA	150	787	0
Chilko & Chilcotin Rivers	72/73	NA	NA	NA	NA	582	343	925	71	0
Dean River	72/73	NA	NA	NA	NA	NA	NA	354	942	0
Chilko & Chilcotin Rivers	73/74	NA	NA	NA	NA	440	199	639	14	0
Dean River	73/74	NA	NA	NA	NA	NA	NA	1339	1378	0
Dean River	74/75	NA	NA	NA	NA	NA	NA	796	1425	0
Dean River	75/76	NA	NA	NA	NA	NA	NA	1309	1327	0
Kispiox River	75/76	NA	NA	NA	NA	350	452	NA	3335	0
Chilko & Chilcotin Rivers	76/77	NA	NA	NA	NA	538	296	834	105	0
Morice River	76/77	NA	NA	NA	NA	497	804	1301	202	0
Thompson River	76/77	NA	NA	NA	NA	#211	#1764	1975	205	139
Atnarko & Bella Coola Rivers	77/78	NA	NA	NA	NA	757	1894	2651	415	546
Chilko & Chilcotin Rivers	77/78	NA	NA	NA	NA	226	82	308	44	0
Morice River	77/78	NA	NA	NA	NA	555	681	1236	191	0
Thompson River	77/78	NA	NA	NA	NA	NA	NA	3762	376	42
Chilko & Chilcotin Rivers	78/79	NA	NA	NA	NA	112	87	199	33	0
Clore River	78/79	NA	NA	NA	NA	84	33	117	12	0
Thompson River	78/79	NA	NA	NA	NA	#652	#2642	3294	431	113
Zymoetz River	78/79	NA	NA	NA	NA	599	305	904	182	0
Chilko River	79/80	NA	NA	NA	NA	233	43	276	57	0
Clore River	79/80	NA	NA	NA	NA	147	25	172	11	0
Zymoetz River	79/80	NA	NA	NA	NA	673	123	796	75	0
Chilko & Chilcotin Rivers	80/81	313	365	678	61	204	101	305	57	0
Thompson River	80/81	3052	6278	9330	1236	#304	#2735	3039	473	0

Table A9 continued.—Data available for comparison of the estimated number of angler days, stratified by residency, from **Field** studies and the **SHA**.

		SHA				Field				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Chilko & Chilcotin Rivers	81/82	NA	NA	NA	NA	193	79	272	59	0
Thompson River	81/82	NA	NA	NA	NA	#1003	#4766	5769	723	0
Chilko & Chilcotin Rivers	82/83	447	100	547	61	221	65	286	35	0
Thompson River	82/83	3646	7375	11021	1219	#500	#3284	3784	720	0
Bulkley River	83/84	6793	2387	9180	1169	NA	NA	2873	431	0
Chilko & Chilcotin Rivers	83/84	579	90	669	21	289	51	340	13	0
Thompson River	83/84	3428	7515	10943	1365	#1018	#4453	5471	891	0
Chilko & Chilcotin Rivers	84/85	488	102	590	4	169	42	211	6	0
Thompson River	84/85	4195	8006	12201	1194	#1694	#6036	7730	904	0
Dean River	87/88	799	1999	2798	3088	NA	NA	1724	2494	0
Dean River	88/89	432	1749	2181	3677	NA	NA	2074	2931	0
Dean River	89/90	231	2296	2527	3720	NA	NA	2040	3012	0
Dean River	90/91	535	1815	2350	3112	NA	NA	1751	2405	0
Dean River	91/92	201	1628	1829	2725	NA	NA	1563	2283	0
Dean River	92/93	398	3067	3465	2558	NA	NA	1535	2073	0
Dean River	93/94	380	1407	1787	3001	NA	NA	1858	2625	0
Dean River	94/95	509	1517	2026	2208	NA	NA	1468	2608	0
Dean River	95/96	407	2227	2634	2217	NA	NA	NA	NA	0
Dean River	96/97	NA	NA	NA	NA	NA	NA	1048	2778	0

Table A10.—Data available for comparison of the estimated catch (retained and released), stratified by residency, from **Field** studies and the **SHA**. **Local** = anglers resident in the BCE region enclosing the stream; **other BC** = BC anglers residing in a region other than that containing the stream; **all BC** = all BC anglers; **NR** = non-residents of BC. NA = value not estimable from available results. The # symbol indicates that field and SHA values are not strictly comparable, usually due to varying residency definitions by field studies.

		SHA				Field				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Chilko & Chilcotin Rivers	72/73	NA	NA	NA	NA	56	49	105	0	0
Chilko & Chilcotin Rivers	73/74	NA	NA	NA	NA	38	14	52	0	0
Kispiox River	75/76	NA	NA	NA	NA	105	109	214	821	0
Chilko & Chilcotin Rivers	76/77	NA	NA	NA	NA	38	10	48	0	0
Morice River	76/77	NA	NA	NA	NA	NA	NA	340	54	0
Thompson River	76/77	NA	NA	NA	NA	#79	#432	511	70	5
Chilko & Chilcotin Rivers	77/78	NA	NA	NA	NA	60	44	104	57	0
Morice River	77/78	NA	NA	NA	NA	NA	NA	465	162	0
Thompson River	77/78	NA	NA	NA	NA	NA	NA	790	85	50
Chilko & Chilcotin Rivers	78/79	NA	NA	NA	NA	13	6	19	6	0
Clore River	78/79	NA	NA	NA	NA	NA	NA	34	3	0
Thompson River	78/79	NA	NA	NA	NA	#128	#557	685	96	10
Zymoetz River	78/79	NA	NA	NA	NA	NA	NA	173	56	0
Chilko & Chilcotin Rivers	79/80	NA	NA	NA	NA	49	17	66	19	0
Clore River	79/80	NA	NA	NA	NA	NA	NA	48	1	0
Zymoetz River	79/80	NA	NA	NA	NA	NA	NA	115	12	0
Chilko & Chilcotin Rivers	80/81	NA	NA	NA	NA	36	9	45	32	0
Thompson River	80/81	NA	NA	NA	NA	#53	#570	624	79	0
Chilko & Chilcotin Rivers	81/82	NA	NA	NA	NA	63	9	72	36	0
Thompson River	81/82	NA	NA	NA	NA	#178	#976	1154	187	0
Chilko & Chilcotin Rivers	82/83	NA	NA	NA	NA	102	8	110	25	0
Thompson River	82/83	NA	NA	NA	NA	#101	#842	943	164	0
Chilko & Chilcotin Rivers	83/84	139	23	162	2	109	12	121	0	0
Thompson River	83/84	512	2411	2923	548	#103	#789	892	238	0

Table A10 continued.—Data available for comparison of the estimated catch (retained and released), stratified by residency, from **Field** studies and the **SHA**.

		SHA				**Field**				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Chilko & Chilcotin Rivers	84/85	240	69	309	0	71	11	82	1	0
Thompson River	84/85	1299	5096	6395	1005	#407	#2670	3077	482	0
Dean River	88/89	331	1815	2146	4791	NA	NA	1063	2015	0
Dean River	89/90	280	2730	3010	5403	NA	NA	1128	2502	0
Dean River	90/91	284	1375	1659	4019	NA	NA	820	2453	0
Dean River	91/92	226	1402	1628	3674	NA	NA	743	2084	0
Dean River	92/93	274	1867	2141	4029	NA	NA	744	2356	0
Dean River	93/94	169	748	917	3999	NA	NA	743	2320	0
Dean River	94/95	232	1483	1715	2908	NA	NA	751	2529	0
Dean River	96/97	NA	NA	NA	NA	NA	NA	538	3136	0

Table A11.—Data available for comparison of the estimated number of steelhead retained, stratified by residency, from **Field** studies and the **SHA**. **Local** = anglers resident in the BCE region enclosing the stream; **other BC** = BC anglers residing in a region other than that containing the stream; **all BC** = all BC anglers; **NR** = non-residents of BC. NA = value not estimable from available results. The # symbol indicates that field and SHA values are not strictly comparable, usually due to varying residency definitions by field studies.

		SHA				**Field**				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Kispiox River	75/76	62	82	144	103	15	36	51	183	0
Morice River	76/77	93	408	501	52	NA	NA	247	32	0
Chilko & Chilcotin Rivers	77/78	162	1	163	92	55	16	71	3	0
Morice River	77/78	152	356	508	122	NA	NA	333	83	0
Thompson River	77/78	384	837	1221	136	NA	NA	654	72	44
Chilko & Chilcotin Rivers	78/79	23	14	37	0	11	6	17	1	0
Clore River	78/79	12	3	15	0	NA	NA	15	2	0

Table A11 continued.—Data available for comparison of the estimated number of steelhead retained, stratified by residency, from **Field** studies and the **SHA**.

		SHA				**Field**				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Thompson River	78/79	348	558	906	147	#122	#437	559	82	8
Zymoetz River	78/79	212	126	338	40	NA	NA	100	19	0
Chilko & Chilcotin Rivers	79/80	62	17	79	1	39	9	48	2	0
Clore River	79/80	21	6	27	5	NA	NA	17	1	0
Zymoetz River	79/80	186	76	262	4	NA	NA	71	7	0
Chilko & Chilcotin Rivers	80/81	30	3	33	0	21	6	27	0	0
Thompson River	80/81	301	686	987	183	#48	#383	431	52	0
Chilko & Chilcotin Rivers	81/82					32	4	36	0	0
Thompson River	81/82					#142	#528	670	110	0
Chilko & Chilcotin Rivers	82/83	50	18	68	0	42	8	50	0	0
Thompson River	82/83	531	1103	1634	188	#83	#476	559	89	0
Chilko & Chilcotin Rivers	83/84	58	17	75	2	32	8	40	0	0
Chilko & Chilcotin Rivers	84/85	75	17	92	0	28	6	34	0	0
Dean River	88/89	34	159	193	65	NA	NA	115	33	0
Dean River	89/90	21	151	172	60	NA	NA	99	37	0
Dean River	90/91	3	0	3	0	NA	NA	0	0	0
Dean River	91/92	3	0	3	9	NA	NA	0	0	0
Dean River	92/93	0	13	13	0	NA	NA	0	0	0
Dean River	93/94	0	0	0	9	NA	NA	0	0	0
Dean River	94/95	0	0	0	0	NA	NA	0	0	0
Dean River	96/97					NA	NA	0	0	0

Table A12.—Data available for comparison of the estimated number of steelhead released, stratified by residency, from **Field** studies and the **SHA**. **Local** = anglers resident in the BCE region enclosing the stream; **other BC** = BC anglers residing in a region other than that containing the stream; **all BC** = all BC anglers; **NR** = non-residents of BC. NA = value not estimable from available results. The # symbol indicates that field and SHA values are not strictly comparable, usually due to varying residency definitions by field studies.

		SHA				Field				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Kispiox River	75/76	NA	NA	NA	NA	90	73	163	638	0
Morice River	76/77	NA	NA	NA	NA	NA	NA	93	22	0
Chilko & Chilcotin Rivers	77/78	NA	NA	NA	NA	5	28	33	54	0
Morice River	77/78	NA	NA	NA	NA	NA	NA	132	79	0
Thompson River	77/78	NA	NA	NA	NA	NA	NA	138	8	9
Chilko & Chilcotin Rivers	78/79	NA	NA	NA	NA	2	6	8	5	0
Clore River	78/79	NA	NA	NA	NA	NA	NA	19	1	0
Thompson River	78/79	NA	NA	NA	NA	#6	#120	126	14	2
Zymoetz River	78/79	NA	NA	NA	NA	NA	NA	73	37	0
Chilko & Chilcotin Rivers	79/80	NA	NA	NA	NA	10	8	18	17	0
Clore River	79/80	NA	NA	NA	NA	NA	NA	31	0	0
Zymoetz River	79/80	NA	NA	NA	NA	NA	NA	44	5	0
Chilko & Chilcotin Rivers	80/81	NA	NA	NA	NA	15	3	18	32	0
Thompson River	80/81	NA	NA	NA	NA	#5	#187	193	27	0
Chilko & Chilcotin Rivers	81/82	NA	NA	NA	NA	31	5	36	36	0
Thompson River	81/82	NA	NA	NA	NA	#36	#448	484	78	0
Chilko & Chilcotin Rivers	82/83	NA	NA	NA	NA	60	0	60	25	0
Thompson River	82/83	NA	NA	NA	NA	#18	#366	384	75	0
Chilko & Chilcotin Rivers	83/84	81	6	87	0	77	4	81	0	0
Chilko & Chilcotin Rivers	84/85	165	52	217	0	43	5	48	1	0
Dean River	88/89	297	1656	1953	4726	NA	NA	938	1982	0
Dean River	89/90	259	2579	2838	5343	NA	NA	1029	2465	0
Dean River	90/91	281	1375	1656	4019	NA	NA	820	2453	0
Dean River	91/92	223	1402	1625	3665	NA	NA	743	2084	0

Table A12 continued.—Data available for comparison of the estimated number of steelhead released, stratified by residency, from **Field** studies and the **SHA**.

		SHA				Field				
Stream	**Year**	**Local**	**other BC**	**all BC**	**NR**	**Local**	**other BC**	**all BC**	**NR**	**Unknown**
Dean River	92/93	274	1854	2128	4029	NA	NA	744	2356	0
Dean River	93/94	169	748	917	3990	NA	NA	743	2320	0
Dean River	94/95	232	1483	1715	2908	NA	NA	751	2529	0
Dean River	96/97	NA	NA	NA	NA	NA	NA	538	3136	0

APPENDIX VII. BOOTSTRAPPED STANDARD ERROR ESTIMATES

Table A13.—Bootstrapped standard errors for SHA fishery parameters. Forty-three fisheries, each comprising the estimated activity on a single **Stream** in a single licence **Year**, were selected for analysis. For each parameter the mean of 500 bootstrap run **Estimates** is given, along with the estimated **Standard Error**, which is the standard deviation of run results. Parameters are: **AD** = angler days, **K** = steelhead retained, **R** = steelhead released, **A** = individual anglers. The results are stratified by angler residency.

		Local Resident Anglers								Other BC Anglers							
		Estimate				Standard Error				Estimate				Standard Error			
Year	**Stream**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**
1984	Chilliwack R	16441	835	8574	1927	1590	162	1467	76	128	17	100	55	54	10	94	19
1985	Chilliwack R	32836	2251	22850	3470	2076	194	2900	48	420	31	274	151	103	19	170	28
1983	Thompson R	4367	599	279	604	529	105	89	27	9034	1280	2041	1946	647	170	497	75
1984	Thompson R	3397	294	210	447	523	85	83	31	7265	957	1283	1530	565	151	303	72
1985	Thompson R	4161	728	571	620	443	96	147	28	7805	1345	3692	1769	546	136	732	67
1983	Chilcotin River	478	62	125	112	181	25	105	24	136	28	26	41	71	17	40	17
1984	Chilcotin River	493	56	66	147	126	21	51	27	88	19	6	37	35	12	8	15
1985	Chilcotin River	451	77	158	175	85	24	72	27	92	17	53	42	44	9	47	14
1983	Chilko R	28	4	0	16	19	6		10	18	0	0	10	17			9
1984	Chilko R	91	0	3	20	65		4	11	0	0	0	0				
1985	Chilko R	55	4	0	15	46	5		9	6	0	0	3	9			5
1985	Dean R	772	77	729	116	348	26	266	22	1114	231	2264	241	188	49	530	35
1990	Dean R	226	19	371	51	82	9	231	15	2351	157	2792	291	674	33	986	44
1995	Dean R	523	0	246	66	160		86	15	1680	0	1395	162	483		420	29
1983	Bulkley R	9020	1083	2458	870	970	147	560	47	2263	354	881	535	355	66	354	51
1984	Bulkley R	6693	632	2006	655	1013	141	513	56	2121	296	668	533	310	66	221	57
1990	Bulkley R	3742	11	2493	485	616	10	828	41	2097	32	1380	354	512	20	404	48
1990	Clore R	25	0	5	11	26		7	10	0	0	0	0				
1985	Cranberry River	353	87	350	88	133	31	135	20	228	89	257	79	59	25	103	16
1990	Cranberry River	268	0	499	53	137		274	19	286	0	68	55	164		62	19
1995	Cranberry River	95	0	279	41	39		219	15	27	0	46	18	14		46	9

Table A13 continued.—Bootstrapped standard errors, SHA fishery parameters, for 43 British Columbia steelhead fisheries. Values are for local residents and BC residents.

		Local Resident Anglers								Other BC Anglers							
		Estimate				Standard Error				Estimate				Standard Error			
Year	**Stream**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**
1985	Damdochax Cr	0	0	0	0					0	0	0	0				
1990	Damdochax Cr	20	0	20	7	23		23	8	0	0	0	0				
1995	Damdochax Cr	0	0	0	0					19	0	10	2	25		12	3
1985	Gitnadoix R	3	0	3	3	5		5	5	3	0	0	3	4			4
1990	Gitnadoix R	199	2	146	38	131	5	103	16	4	4	0	4	5	5		5
1995	Gitnadoix R	45	0	71	15	36		101	10	6	0	0	3	7			4
1985	Ishkheenickh R	80	25	132	31	41	15	100	15	38	13	65	9	31	12	65	7
1990	Ishkheenickh R	58	29	358	30	32	16	352	15	21	16	62	4	31	25	92	6
1995	Ishkheenickh R	66	9	124	29	34	10	67	13	0	0	0	0				
1990	Kispiox R	375	0	144	124	87		65	20	225	0	96	82	69		56	20
1997	Kispiox R	593	10	92	149	150	9	38	25	444	0	311	126	130		209	31
1985	Kitimat R	3191	382	524	277	719	87	194	32	223	28	13	51	100	21	11	17
1990	Kitimat R	6991	778	3962	763	1136	152	960	53	1264	114	496	276	352	39	244	38
1995	Kitimat R	5230	522	2475	605	652	89	563	42	1498	212	810	294	228	58	182	33
1990	Skeena R	9659	245	1573	914	1295	59	345	53	2053	90	171	492	277	24	61	52
1985	Tseax R	395	64	199	95	187	42	102	21	46	7	22	19	31	10	31	11
1990	Tseax R	235	9	93	60	134	11	56	22	79	4	5	23	59	5	7	13
1995	Tseax R	73	0	21	31	45		21	13	25	0	0	21	12			10
1990	Zymoetz R	1072	39	853	203	277	28	379	31	379	4	302	145	112	5	217	36
1985	Pallant Cr	410	67	587	46	179	38	304	17	29	6	101	12	23	11	112	9
1990	Pallant Cr	97	7	80	45	42	7	63	19	16	0	3	8	17		6	8
1995	Pallant Cr	150	7	262	35	109	11	241	14	18	0	15	12	14		15	9

Table A13 continued.—Bootstrapped standard errors of SHA fishery parameters, for 43 British Columbia steelhead fisheries. Values are for non-residents, and all residencies totaled.

		Non-Residents of BC								Total, All Residencies							
		Estimate				Standard Error				Estimate				Standard Error			
Year	**Stream**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**	**AD**	**K**	**R**	**A**
1984	Chilliwack R	56	12	12	17	39	14	16	8	16625	863	8686	1999	1589	163	1471	78
1985	Chilliwack R	229	10	109	46	74	8	48	10	33485	2292	23233	3668	2074	195	2901	57
1983	Thompson R	1279	204	331	228	190	47	111	18	14679	2083	2651	2778	864	210	524	81
1984	Thompson R	1326	170	364	215	214	43	145	19	11987	1421	1856	2192	843	190	349	80
1985	Thompson R	1141	217	728	206	142	37	195	17	13107	2290	4991	2595	711	173	778	72
1983	Chilcotin River	48	0	29	9	45		37	5	662	89	180	162	196	30	117	29
1984	Chilcotin River	18	3	0	13	11	3		7	599	78	72	197	135	24	52	32
1985	Chilcotin River	3	0	0	3	3			3	547	94	211	220	93	25	84	30
1983	Chilko R	7	0	0	5	6			4	52	4	0	31	24	6		13
1984	Chilko R	2	0	0	2	3			3	94	0	3	23	65		4	11
1985	Chilko R	0	0	0	0					61	4	0	18	47	5		10
1985	Dean R	1597	110	4155	275	134	23	489	20	3482	418	7149	631	417	60	758	45
1990	Dean R	3541	61	5069	577	237	28	559	34	6118	237	8232	919	728	45	1155	60
1995	Dean R	2090	0	2788	365	192		365	29	4293	0	4429	592	529		569	43
1983	Bulkley R	1668	205	789	307	182	43	200	21	12951	1642	4128	1711	1042	169	668	74
1984	Bulkley R	1014	106	517	242	168	27	156	25	9828	1035	3191	1430	1080	153	569	85
1990	Bulkley R	2278	19	1888	452	256	19	305	28	8117	62	5761	1291	821	28	947	70
1990	Clore R	0	0	0	0					25	0	5	11	26		7	10
1985	Cranberry River	97	16	8	30	37	8	7	8	678	191	615	198	149	41	171	26
1990	Cranberry River	97	0	47	30	45		37	10	651	0	614	138	234		284	29
1995	Cranberry River	2	0	0	2	3			3	125	0	326	61	41		221	18
1985	Damdochax Cr	69	27	75	16	31	25	46	7	69	27	75	16	31	25	46	7
1990	Damdochax Cr	99	0	72	17	41		49	7	119	0	92	24	47		55	10
1995	Damdochax Cr	173	0	225	29	65		113	11	193	0	234	31	70		115	11

Table A13 continued.—Bootstrapped standard errors of SHA fishery parameters, for 43 British Columbia steelhead fisheries. Values are for non-residents, and all residencies totaled.

		Non-Residents of BC								Total, All Residencies							
		Estimate				Standard Error				Estimate				Standard Error			
Year	Stream	AD	K	R	A	AD	K	R	A	AD	K	R	A	AD	K	R	A
1985	Gitnadoix R	0	0	0	0					6	0	3	6	6		5	6
1990	Gitnadoix R	2	0	0	2	3			3	205	6	146	43	132	7	103	18
1995	Gitnadoix R	0	0	0	0					51	0	71	18	37		101	11
1985	Ishkheenickh R	14	1	1	6	15	2	2	4	132	39	198	45	52	19	117	17
1990	Ishkheenickh R	9	0	0	2	13			3	88	45	419	36	46	29	361	17
1995	Ishkheenickh R	0	0	0	0					66	9	124	29	34	10	67	13
1990	Kispiox R	1838	12	1491	373	283	11	423	35	2438	12	1730	579	300	11	435	43
1997	Kispiox R	2860	0	1596	484	337		300	27	3897	10	1999	759	386	9	361	47
1985	Kitimat R	46	11	27	23	23	12	18	7	3460	421	563	351	728	90	195	38
1990	Kitimat R	563	141	114	119	111	51	45	15	8819	1033	4573	1158	1197	167	991	67
1995	Kitimat R	546	35	221	122	122	16	72	19	7274	769	3506	1022	715	108	599	57
1990	Skeena R	3694	296	452	522	446	60	93	34	15405	631	2197	1929	1391	88	371	83
1985	Tseax R	14	0	2	6	11		3	4	455	71	222	121	190	43	108	25
1990	Tseax R	29	0	0	9	21			6	343	13	98	92	145	11	57	27
1995	Tseax R	9	0	7	7	8		7	6	107	0	28	60	48		23	18
1990	Zymoetz R	304	3	212	81	70	4	75	12	1756	45	1367	429	302	29	442	48
1985	Pallant Cr	6	0	15	3	6		18	3	445	73	704	61	180	39	328	19
1990	Pallant Cr	21	8	11	7	18	8	10	6	134	15	94	61	49	10	64	21
1995	Pallant Cr	11	5	0	7	10	5		6	179	11	277	54	112	12	243	18

Region	Stream	Ecotype	Season	Responses	^Anglers	^Days	^Wild_Kept	^Wild_Rel	^Hatch_Kept	^Hatch_Rel	^Wild_Tot	^Hatch_Tot	^Kept_Tot	^Rel_Tot	^Catch_Tot	New WSC
2	ASHLU CREEK	W	2016/2017	4	21	43	0	11	0	0	11	0	0	11	11	900-097600-38300-00000-0000-0000-000-000-000-000-000-000
2	ASHLU CREEK	W	2017/2018	1	5	5	0	0	0	0	0	0	0	0	0	900-097600-38300-00000-0000-0000-000-000-000-000-000-000
2	ASHLU CREEK	W	2018/2019	1	5	16	0	0	0	0	0	0	0	0	0	900-097600-38300-00000-0000-0000-000-000-000-000-000-000
2	ASHLU CREEK	W	2019/2020	3	16	16	0	0	0	0	0	0	0	0	0	900-097600-38300-00000-0000-0000-000-000-000-000-000-000
2	CHEAKAMUS RIVER	W	2016/2017	79	409	2173	0	365	0	27	365	27	0	392	392	900-097600-12900-00000-0000-0000-000-000-000-000-000-000
2	CHEAKAMUS RIVER	W	2017/2018	72	353	1785	0	332	0	0	332	0	0	332	332	900-097600-12900-00000-0000-0000-000-000-000-000-000-000
2	CHEAKAMUS RIVER	W	2018/2019	62	298	1411	0	360	0	38	360	38	0	397	397	900-097600-12900-00000-0000-0000-000-000-000-000-000-000
2	CHEAKAMUS RIVER	W	2019/2020	70	368	1762	0	692	0	21	692	21	0	713	713	900-097600-12900-00000-0000-0000-000-000-000-000-000-000
2	ELAHO RIVER	W	2016/2017	0	0	0	0	0	0	0	0	0	0	0	0	900-097600-70400-00000-0000-0000-000-000-000-000-000-000
2	ELAHO RIVER	W	2017/2018	0	0	0	0	0	0	0	0	0	0	0	0	900-097600-70400-00000-0000-0000-000-000-000-000-000-000
2	ELAHO RIVER	W	2018/2019	0	0	0	0	0	0	0	0	0	0	0	0	900-097600-70400-00000-0000-0000-000-000-000-000-000-000
2	ELAHO RIVER	W	2019/2020	0	0	0	0	0	0	0	0	0	0	0	0	900-097600-70400-00000-0000-0000-000-000-000-000-000-000
2	MAMQUAM RIVER	W	2016/2017	4	21	69	0	0	0	0	0	0	0	0	0	900-097600-05100-00000-0000-0000-000-000-000-000-000-000
2	MAMQUAM RIVER	W	2017/2018	4	17	90	0	0	0	0	0	0	0	0	0	900-097600-05100-00000-0000-0000-000-000-000-000-000-000
2	MAMQUAM RIVER	W	2018/2019	4	18	104	0	0	0	0	0	0	0	0	0	900-097600-05100-00000-0000-0000-000-000-000-000-000-000
2	MAMQUAM RIVER	W	2019/2020	7	35	253	0	43	0	27	43	27	0	71	71	900-097600-05100-00000-0000-0000-000-000-000-000-000-000
2	SQUAMISH RIVER	W	2016/2017	111	544	3078	0	186	0	0	186	0	0	186	186	900-097600-00000-00000-0000-0000-000-000-000-000-000-000
2	SQUAMISH RIVER	W	2017/2018	105	497	2304	0	224	0	5	224	5	0	229	229	900-097600-00000-00000-0000-0000-000-000-000-000-000-000
2	SQUAMISH RIVER	W	2018/2019	98	457	2059	0	157	0	0	157	0	0	157	157	900-097600-00000-00000-0000-0000-000-000-000-000-000-000
2	SQUAMISH RIVER	W	2019/2020	90	455	2682	0	145	0	21	145	21	0	166	166	900-097600-00000-00000-0000-0000-000-000-000-000-000-000