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Accuracy and Utility of the Atlantic Salmon Licence Stub (Angler Log) Return Program in Newfoundland and Labrador

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Foreword

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ABSTRACT

The accuracy of the licence stub program is dependent on a high level of compliance by anglers. At the population level the uncertainty in the estimate of average harvest per angler is acceptable. Other population level metrics obtained from the data such as number of released fish and effort are likely estimated with similar margins-of-error and confidence. On a river by river basis the estimated number of harvested fish becomes less certain as fewer anglers submit river specific returns or are polled during a telephone survey. DFO Science and resource managers need to determine what level of risk is acceptable. There is little doubt that the licence stub program is useful. The data is used for multiple purposes including annual stock assessments, to meet international obligations, and to evaluate the impact of management measures such as implementation of the River Classification System. The licence stub program contains demographic and catch data that may be valuable to the fishing industry such as the origin of anglers fishing different rivers, rivers with the highest catch per unit effort, and rivers with the highest catch of large fish. It may also be possible to expand the number of rivers upon which stock assessments are carried out based on the licence stub data**.**

Précision et utilité du Programme de retour des talons de permis de pêche au saumon de l'Atlantique (registre des pêcheurs à la ligne) à Terre-Neuve-et-Labrador

RÉSUMÉ

La précision du programme des talons de permis dépend d'un degré de conformité élevé des pêcheurs à la ligne. Au niveau de la population, l'incertitude dans l'estimation de la moyenne des prises par pêcheur est acceptable. D'autres mesures au niveau de la population obtenues à partir des données, telles que le nombre de poissons relâchés et l'effort, sont probablement estimées avec des marges d'erreur et un indice de confiance semblables. Rivière par rivière, le nombre estimé de poissons pêchés devient moins certain, car moins de pêcheurs soumettent des retours de talons propres à une rivière ou sont interrogés lors de sondages téléphoniques. Le Secteur des sciences du MPO et les gestionnaires des ressources doivent déterminer quel niveau de risque est acceptable. Il ne fait aucun doute que le programme des talons de permis est utile. Les données sont utilisées à diverses fins, y compris les évaluations annuelles des stocks, pour respecter les obligations internationales et évaluer les répercussions des mesures de gestion telles que la mise en œuvre du système de classification des rivières. Le programme des talons de permis contient des données sur les prises et des données démographiques qui peuvent être utiles à l'industrie de la pêche, comme l'origine des pêcheurs pratiquant la pêche dans différentes rivières, les rivières ayant la prise par unité d'effort la plus élevée et les rivières ayant la prise de gros poisson la plus élevée. Il peut être également possible d'augmenter le nombre de rivières pour lesquelles des évaluations des stocks sont effectuées en fonction des données sur les talons de permis**.**

INTRODUCTION

In Newfoundland and Labrador (NL) the recreational Atlantic Salmon fishery is regulated by the province of NL and the federal Department of Fisheries and Oceans (DFO). Salmon anglers must obtain and possess a valid salmon licence to legally fish. The province prints and distributes the licences to vendors who then sell them to anglers. Prior to 1994, information on salmon angler catch and effort was collected by DFO fishery officers or River Guardians (O'Connell et al 1998). According to O'Connell et al (1998) there was concern that this approach might be producing unreliable results owing to an increased emphasis being placed on enforcement, and therefore less effort on the collection of angling data. Further, the angling data was collected more or less opportunistically and therefore was not statistically robust. Consequently, starting in 1994, the provincial recreational salmon licence included an angler log or stub (in duplicate) as well as a duplicate copy of the angler application information referred to as the vendor's sales slip (O'Connell et al 1998). The vendor's sales slip is used to record information identifying the angler (name, address, gender, and proof of residency) (Figure 1 top), and at the time of sale is retained by the vendor. The angler stub or log (Figure 1 bottom) is retained by the angler, and anglers are asked to keep a record of their fishing activities (catch, effort, rivers fished, etc.) throughout the fishing season. Vendors are expected to return one copy of the sales slip to the province and the other to DFO. Anglers are asked to submit their angling data electronically through DFO's web page or mail their log to DFO at the end of the angling season regardless of whether or not they fished. DFO then compiles and analyzes the data obtained from the vendors and anglers.

The purpose of this working paper is to examine the accuracy and utility of the licence stub program. The paper first describes the survey methods DFO uses to obtain returns from anglers, and then describes the method used to extrapolate information from the survey to the total angling population and to apportion catch on a river by river basis. The terms accuracy and utility are defined and the program is examined in light of those definitions. For the purposes of this paper, Atlantic Salmon refers to the wild anadromous form of the species.

METHODS

LICENCE STUB

The design of the DFO licence stub program was based on O'Neil et al. (1986) and O'Neil et al. (1987). Between 1994 and 1997 anglers were asked to return their angler logs and those that did within a certain time frame were classified as voluntary. After the voluntary time period expired, usually around mid-October, "reminders to anglers" were sent, at regular intervals over the next 3-6 months, to any angler who did not voluntarily return their log. Responses to these reminders were labelled Post Prompt 1, 2 and 3. "Respondents" consisted of any logs received voluntarily or from any of the three prompts. The remaining angling population made up the "Non-respondents" category. Catch and effort were extrapolated from the Respondents population to the Non-respondents population using a regression method developed from the cumulative number of Respondents in each response group and their cumulative catch and effort (O'Connell et al 1998; O'Neil et al 1987; O'Neil et al 1986). Total catch and effort were apportioned to individual rivers based on the proportion of catch and effort reported by the Respondents and estimated for the Non-respondents for each river (See O'Connell et al. 1998 for equations).

By 1997 it was observed that an unusually large number of anglers were reporting catch during every fishing trip. Therefore from 1997 to 1999 a phone survey was carried out to estimate the

amount of unreported effort in the data. Effort is measured in “rod days” where a rod day is defined as all or any part of a day fished by an angler. A random sample of anglers that reported catch during every fishing trip was surveyed to determine whether they were reporting successful angling trips only and omitting fishing trips (effort) where there was no catch.

In 1998 DFO began a phone survey of Non-respondents to correct for non-response bias in the data (i.e., the responses of anglers who submit their logs differ from those who do not). Data from 1994-1997 were then recalculated based on the 1998 phone survey information. Since then approximately 5000 names are randomly selected annually from the list of Non-respondents, and anglers from that list are called until approximately 2000 Non-respondent surveys are completed or the contracted budget is consumed. Non-respondents are questioned about their angling catch and effort which produces data comparable to what is recorded in the angler log. To extrapolate total catch, for example, to the whole Non-respondent population it is assumed that the phone survey sample is representative of the population and, therefore, total catch is simply estimated based on the average catch from the phone survey sample multiplied by the total number of Non-respondents in the angling population (Equation 1.).

$$C_{nr} = \bar{C}_{nr} * N_{nr} \qquad \text{Equation 1.}$$

Where C_{nr} = Total catch by Non-respondents

$\bar{C}_{nr}$ = Mean catch per surveyed Non-respondent fishing, and

N_{nr} = Total number of Non-respondents fishing.

Equations of the same format are used to calculate total number of small salmon kept, small salmon released, effort, etc. Total catch for the angling population is the sum of the reported catch by Respondents plus the estimated total catch of the Non-respondents. To apportion catch on a river by river basis the total number of small salmon kept, for example, is apportioned based on the proportion of small salmon reported kept or estimated kept for Respondents and/or Non-respondents for that river using the following conditions:

1. If the number of unique anglers (licence numbers) in the Non-respondent phone survey fishing a given river is greater than 15, then the estimated catch for that river is the sum of the actual catch reported by Respondents for that river plus the estimated catch of the Non-respondents fishing that river (Equation 2). The estimated catch of the Non-respondents is calculated based on the proportion of Non-respondents fishing that river multiplied by the average catch of the Non-respondents fishing that river.

$$C_{Ri} = \left(\left(\frac{N_{Ri}}{N_S} * N_{nr}\right) * \bar{C}_{nr_{Ri}}\right) + C_{r_{Ri}} \qquad \text{Equation 2.}$$

Where C_{Ri} = Total catch on river i

N_{Ri} = Number of surveyed Non-respondents fishing river i

N_S = Total number of Non-respondents fishing (null-effort removed) who were surveyed

N_{nr} = Total number of Non-respondents fishing

$\bar{C}_{nr_{Ri}}$ = Mean catch of surveyed Non-respondents on river i

$C_{r_{Ri}}$= Total catch reported by Respondents on river i

2. If the number of unique anglers (licence numbers) in the Non-respondent phone survey fishing a given river is less than 15, then the estimated catch for that river is based on the proportion of Respondents total catch reported for that river multiplied by the estimated total catch for the entire angling population (Equation 3.).

$$C_{Ri} = \frac{C_{r_{Ri}}}{C_r} * C_S$$

Equation 3.

Where C_{Ri} = Total catch on river i

$C_{r_{Ri}}$ = Total catch reported by Respondents on river i

C_r = Total catch reported by Respondents

C_S = Sum of total catch by Respondents and Non-respondents = $C_r + C_{nr}$

3. If the number of unique anglers (licence numbers) in the Non-respondent phone survey fishing a given river is less than 15, and no Respondents fished that river, then that river is considered data deficient and no catch statistics are generated for that river for that year.

WORKED EXAMPLES

Gander River 2009

In 2009, 1210 anglers were surveyed by phone and 115 of those said they fished Gander River.

N>15 for Gander River therefore Equation 2 is applied.

Number of surveyed Non-respondents fishing Gander River = 115

Total number of Non-respondents fishing who were surveyed in 2009 was 1210

Total number of Non-respondents fishing in 2009 was 11,268

Average number of small salmon retained by surveyed Non-respondents that fished Gander River in 2009 was 0.88.

Total number of small salmon reported retained by Respondents on Gander River in 2009 = 549

Estimated total number of small salmon retained on Gander River in 2009 =

(((115/1210) * 11268) *0.88) + 549 = 1491

Tommy's Arm River 2009

In 2009, 1210 anglers surveyed by phone fished and 4 of those said they fished Tommy's Arm River. N<15 for Tommy's Arm River therefore Equation 3 is applied.

Total number of small salmon reported retained by Respondents fishing Tommy's Arm River in 2009 was 30.

Total number of small salmon reported retained by all Respondents fishing on all rivers was 7188.

Total small salmon reported retained by Respondents and Non-respondents fishing = 23653.

Estimated total number of small salmon retained on Tommy's Arm River =

30/7188 * 23653 = 99

The number of small salmon released, large salmon released and effort are calculated using the same formulae and substituting the appropriate variable for small salmon retained. However, for effort the raw data is adjusted for unreported effort. The surveys carried out between 1997 and 1999 (discussed above) determined that effort was being under-reported because anglers were reporting successful fishing trips only. The average annual amount of unreported effort was estimated at approximately 18 %. Therefore, all raw effort numbers are increased by 18 % to account for the under-reporting. Adjusted effort is used in the above calculations to determine total effort and effort on a river by river basis.

DEFINITION OF TERMS

The terms “accuracy” and utility” were not defined during the advisory meeting from which the request for this evaluation of the licence stub program originated. Therefore, in the context of this report, “accuracy” is defined as proximity to the true answer (i.e. unbiased and precise) and “utility” is defined as useful or being of use.

ESTIMATING MARGINS OF ERROR AND CONFIDENCE INTERVALS IN THE ANGLER SURVEY

Under the licence stub program, anglers are divided into two populations; Respondents and Non-respondents. The Respondents population is defined as anyone who returns their angling information either voluntarily or after one of 3 prompts. Therefore, by definition, the entire Respondent population is surveyed. Any statistic calculated on this group either as a whole or by river is a population parameter and is known absolutely (ignoring for the moment any systematic bias or data entry errors). Variance around parameters such as mean catch per angler can be calculated, but the calculated mean catch is the true mean for that population. The phone survey, however, samples a portion of the Non-respondent population and therefore the uncertainty (accuracy) around the population parameters is based on sampling statistics.

When sampling a portion of a population (Non-respondent salmon anglers in this case) through a phone survey, the accuracy of the survey is evaluated based on the margin of error for the survey and the confidence intervals around the means. These metrics depend on the variance around the parameter of interest (e.g. mean catch per angler) and the proportion of the population surveyed (Pollock et al. 1994). Since angling data consist of a large number of responses with zero catch, it follows a negative binomial distribution rather than a normal distribution (Figure 2). Therefore, the confidence intervals for individual rivers were calculated using Krebs (1999) equation 4.22, which is based on log transformed observations and the student’s t distribution. Once the confidence intervals were calculated for individual rivers, the margin of error on each river could be calculated by re-arranging the Pollock et al. (1994) equation 3.4. Since the number of anglers who reported fishing a specific river was known, the Pollock et al. (1994) equation could be solved for “d” (margin of error). Given that angling data is not normally distributed, the student’s t distribution was used to obtain the appropriate values for the desired confidence interval. However, the total angling population for a given river was not known therefore the finite population correction factor (Pollock et al. 1994) was not made. This will result in more conservative or precautionary estimates of the margins of error. Effort data was treated in the same way, but since null-effort was removed prior to any analyses there was no zero effort. Effort, on an individual river basis was dominated by anglers who only fished one day and therefore still followed a negative binominal distribution.

RESULTS AND DISCUSSION

ACCURACY OF THE LICENCE STUB PROGRAM

The number of licences returned to DFO as a proportion of the total number of licences sold has been declining since the beginning of the program (Figure 3). For the first few years of the program over 50 % of the licences sold were returned by Respondents. More recently that number is down to less than 30 %. In 2012, the most recent year with data available, operational constraints resulted in only 2 reminders being sent to anglers which produced the lowest rate of returns in the history of the program (25 %) (Figure 3). Nevertheless, as was mentioned above, Respondents make up a population within the survey and the data is assumed accurate and used without any adjustments except for effort which is adjusted for unreported effort. Non-respondents are not treated the same as Respondents because the phone survey is only sampling a proportion of the Non-respondent population. Therefore, the accuracy of the phone survey data is assessed based on sampling statistics.

The accuracy of any type of survey data is generally reported as a margin of error and a confidence interval. Often it is stated something like: “This survey is accurate to within plus or minus 3 percentage points 19 times out of 20.” What is being reported, in this example, is a 3 % margin of error and a confidence interval of 95 % (19 out of 20 = 95 %). What, in reality, is being expressed is the probabilities that the same answers would be obtained if the survey were repeated many times.

Based on survey sampling statistics alone it can be shown that for a population of 15,000 (approximate number of Non-respondent anglers in NL annually) only 375 completed surveys are required for the results of a survey to be considered correct (± 5 %) 95 % of the time (Raosoft 2013). In other words, if the survey was repeated many times, the expectation is that the same answer (± 5%) would be obtained 95% of the time. Given that, on average, over 1800 anglers have been surveyed in the last 5 years, these numbers suggest that the licence stub program should produce very accurate data on parameters such as total catch, total effort, average catch per angler, etc. for the entire Non-respondent angling population. However, these values assume no bias in the data. For example, we know there is a difference in the effort and catch reported by Respondents and Non-respondents with Non-respondents reporting nearly twice the effort of Respondents but with less catch (Figure 4). It is possible that this difference is re-call bias (Connelly and Brown 1995) on the part of the Non-respondents because the phone survey takes place in February; 5 months after the closure of the angling season. A phone survey that includes Respondents is being planned to test for re-call bias. Regardless of potential bias in the data, the survey statistics suggest that the sample sizes in the phone survey are large enough to obtain accurate estimates of the total catch and effort anglers recall being engaged in and would not change if the survey was repeated.

When trying to apportion catch or effort to individual rivers, the angling population on that river and the proportion of that population that is captured in the survey greatly affects the margins of error for a given confidence interval (Table 1). As can be seen in figure 5 over 100 anglers in the survey need to be fishing a specific river just to keep the Margin of Error (MoE) between 20 and 40 %. Therefore, on a river like Exploits where approximately 250 surveyed anglers report fishing the Exploits annually, the average catch can be estimated quite accurately (±15 %) 90 % of the time (Table 1). On the other hand, for a river like Harry’s the retained catch can only be estimated to within ± 75 % with 90 % confidence.

Whether these estimates of retained catch are considered “accurate” or more correctly “accurate enough” would depend on what they are being used for. For example, harvest (retained catch) is used in DFO’s annual assessments of the status of salmon stocks in

individual rivers. The number of fish harvested is subtracted from the total returns to the rivers to estimate spawning escapement. On Exploits River the estimated average harvest, based on the MoE at the 90 % Confidence Intervals (CI) (Table 1) is between 1.4 and 1.9 fish per angler. This modest range in values is unlikely to have much impact on the assessment of Exploits River. However, for Harry's River, the average harvest can only be estimated to be between 0.11 and 0.78 fish per angler. This is a seven fold difference between the lower and upper harvest estimate and using the mean value, in the annual assessment, from such a large range may not be viewed as being precautionary. On the other hand if the data is only used to look at general trends in harvest the MoE may be acceptable. Regardless of how the data is being used, the only way to improve on these results is to increase the number of anglers from which angling information is obtained.

Accuracy of the licence stub data could also be evaluated by comparing the licence stub data to a second independent estimate of angler catch and effort. One possible way to obtain a second estimate of catch and effort is through a creel survey (Robson 1960; Malvestuto et al 1978; Pollock et al 1997). Creel surveys involve having personnel on individual rivers observing catch and effort or interviewing anglers on the river or at access points. When carried out over a period of time, properly designed and executed creel surveys can produce estimates of catch and effort with appropriate confidence intervals. Comparing creel survey estimates to the results of the licence stub program would provide an estimate of the accuracy of the licence stub data on an individual river. However, few recent (since the inception of the licence stub program) creel surveys of NL salmon rivers could be found in the literature. O'Connell et al. (1998) compared the first 4 years of the licence stub program to the results of creel surveys on Middle Brook and Pinware River (Mullins and Caines 1998) as well as to the River Guardians' data. For the creel data on Middle Brook and Pinware River, O'Connell et al. (1998) found obvious differences between the methods with "no ready explanation for the lack of correspondence". The greatest differences were in the estimates of effort for which there is now a known significant non-response bias. The best agreement was for small salmon retained, but the agreement was not overly accurate (77 compared to 127 and 279 compared to 432 for creel compared to stub on Middle Brook and Pinware, respectively). When comparing licence stub data to that collected by River Guardians, O'Connell et al. (1998) found that agreement between the two methods was best for small salmon retained at large spatial scales (insular Newfoundland or Labrador) and poorer on an individual river by river basis. At the insular Newfoundland scale the ratio for small salmon kept between the two estimates had a range of 0.96 to 1.06 in 1995 (O'Connell et al 1998).

Mullins and Reddin (1995) conducted a creel survey on Humber River in 1994 and compared their results to the DFO River Guardian data, but unfortunately there was no comparison to the licence stub data. They reported good agreement on small salmon retained on a weekly basis at Big Falls between their creel results and the guardian data. Total catch between the two methods had a ratio of 0.85 (15 % difference). When extrapolating from the catch at Big Falls to the whole river Mullins and Reddin (1995) estimated that the total harvest of small salmon on Humber River was between 2207 and 2942, which is lower than the licence stub value in DFO's data base of 3227 (unpublished data). O'Connell et al. (1998) speculated that if the creel survey is the benchmark, then the licence stub program may be overestimating catch which is supported by the Humber River data. However, all the comparisons thus far were carried out prior to any Non-respondent surveys. The early years of the licence stub program have now been corrected for non-response bias, but still may not be as accurate as more recent surveys. For example, Veinott (2009) carried out a creel survey on a very small system (Renews River) that produced excellent agreement between the creel results and the DFO licence stub data. Veinott (2009) estimated that only 6 fish were harvested in 2007 with 73 rod days of effort, whereas the licence stub data estimated 6 fish harvested in 80 rod days. Although the number

of anglers encountered in the Veinott (2009) creel survey was low, the results suggest that accurate estimates of catch and effort may be possible from the stub data on a river by river basis.

UTILITY OF LICENCE STUB PROGRAM

The licence stub program generates angling data on over 150 rivers annually. The initial intent of the program was to produce harvest estimates to be used in stock assessments and this is still its primary role. In 2013, DFO conducted counts of returning adult Atlantic Salmon on 15 rivers throughout Newfoundland and Labrador. These are considered index rivers on which assessments are carried out. The health of the stock is assessed based on the number of fish that survive to spawn relative to the conservation spawning requirement for that river. The spawning population is estimated from the count of the returning adults minus the in-river harvest in the recreational fishery. No correction is made for in-river natural mortality or illegal harvests. Since DFO does not have an ongoing creel survey program, the only estimate of in-river harvest of Atlantic Salmon is from the licence stub program. Without the program DFO would have to find alternate ways of estimating harvest on their index rivers if assessments were to be carried out.

The angler log data is also used to estimate the total population of adult Atlantic Salmon in insular Newfoundland. Canada is a signatory to the NASCO (North Atlantic Salmon Conservation Organization) convention and under that convention Canada has an obligation to provide data to the ICES (International Council for the Exploration of the Sea) working group on North Atlantic Salmon. Part of the data provided to the ICES working group is an estimate of the total population of adult Atlantic Salmon in the province of NL. To do this, returns to index rivers and the angling data on those rivers are used to calculate exploitation rates. These exploitation rates are then transported to salmon fishing areas with angling data but no adult count. Knowing the in-river harvest and the exploitation rate allows for the adult population to be estimated for the region. Again, without the licence stub program DFO would have to find alternate means of providing the data needed by the ICES working group.

Recently, Veinott et al. (2013) used the angler data to assess the effectiveness of a DFO fisheries management measure: the River Classification System (RCS). In Newfoundland the RCS was designed such that daily and seasonal bag limits for Atlantic Salmon could be set on a river by river basis. Higher class rivers have higher retention limits compared to lower class rivers. The Veinott et al. (2013) study showed that this management strategy resulted in a lowering of the overall harvest of Atlantic Salmon with very little or no change in angling effort. It also showed that harvest shifted away from lower class rivers to higher class rivers and that harvest and effort had little to do with the conservation status of the river.

The licence stub data was also used in a study of changing angler demographics within the fishery (Dempson et al. 2012). That study showed that the average age of anglers had been steadily increasing but in some areas it had recently leveled off. This suggests that younger anglers are beginning to participate in the fishery. Dempson et al. (2012) was also able to track the origin of anglers fishing different rivers. For example, in recent years the origin of anglers fishing Torrent River was primarily the St. John's/Avalon region whereas those fishing Harry's River were predominately local anglers. This would seem to be very valuable information for those involved in the recreational angling industry. Outfitters and guides, for example, would know the age, gender, and origin of their clients and could market or accommodate as necessary. In addition to demographic data the licence stub data can provide industry with data on the busiest (most effort) and/or least fished rivers; rivers with best chance of catching a fish (highest catch per unit effort); and rivers with the best chance of catching a large salmon. Anglers may want to avoid busy rivers at times or join up with other anglers. They may want to

catch their limit or simply fish for that one large trophy. The data necessary to make those decisions is available through the licence stub program.

A potential future use of the licence stub data would be to expand the number of rivers on which individual assessments are carried out. Jansen et al. (2013), for example, concluded that high-quality angler log books could be a cost-effective tool to reveal long term trends in pike populations in Denmark. Dorow and Arlinghause (2011) also highlighted the cost-effectiveness of telephone and diary surveys but warned of re-call bias, and Kerr (2007) concluded that volunteer angler diary programs do provide an accurate and cost-effective means of monitoring the status of muskellunge fisheries in Ontario. The published literature and the evidence of strong correlations between angler-provided data and returns on some of our rivers (Figure 6) certainly suggest that the potential is there to broaden our assessments, although some studies have also suggested that using angling data in an absolute sense to estimate stock size can be quite risky (O'Connell 2003).

CONCLUSIONS

Overall the accuracy of the licence stub program is highly dependent on a high level of compliance by the anglers. At the population level the uncertainty in the estimate of average harvest per angler is acceptable. Other population level metrics obtained from the data such as number of released fish and effort are likely estimated with similar margins-of-error and confidence. On a river by river basis the estimated number of harvested fish becomes less certain as fewer anglers submit returns or are polled. Increasing the number of anglers surveyed would improve this. DFO Science and fisheries managers need to determine the level of risk that is acceptable. There is little doubt that the licence stub program is useful because the data from the program is used annually for a variety of purposes. It may be possible to expand the number of rivers upon which assessments are carried out based on the licence stub data.

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Table 1. Margins of Error (MoE %) for the mean retained catch per angler, mean released catch per angler and mean effort per angler at different confidence intervals (CI) for the rivers listed . N = number of anglers in survey fishing that river. Median values are also provided for information purposes only.

Retained

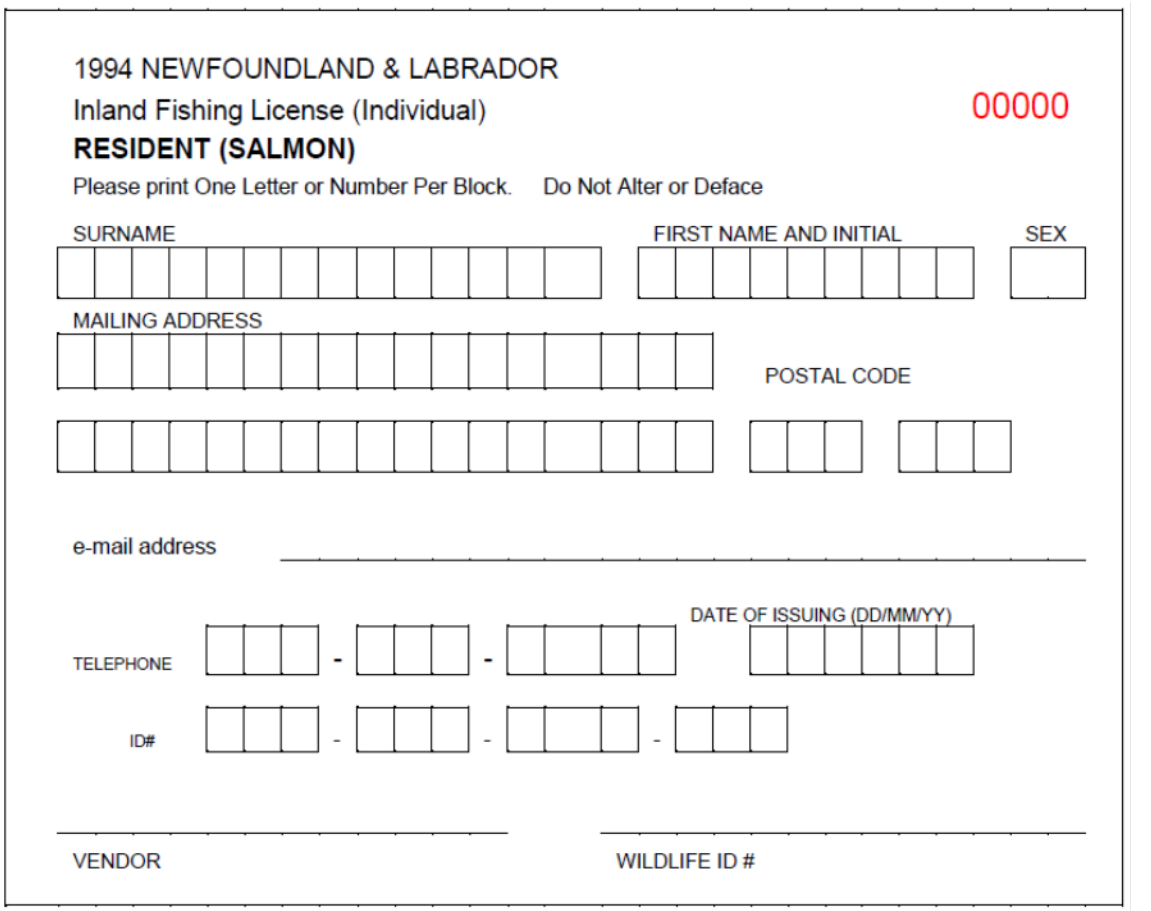
River	Mean Retained Catch/Angler	Median Retained/Angler	N	95% CI MoE (%)	90% CI MoE (%)	80% CI MoE (%)
Exploits R.	1.66	1	249	19.2	15.2	11.3
Humber R.	1.15	0	200	30.1	23.9	17.7
Gander R.	0.88	0	115	37.8	30.0	22.2
Salmon R.	1.39	1	57	42.2	32.4	24.9
Southwest/Bottom Bk.	0.27	0	55	143.2	97.2	62.8
Gambo R.	0.76	0	50	66.4	51.0	39.2
Harry's R.	0.45	0	49	110.4	74.9	48.4
Salmonier R.	0.25	0	48	179.9	122.1	78.9
Grand Codroy R.	0.69	0	36	86.0	66.1	50.7
River of Ponds	1.27	0.5	26	84.9	65.2	50.1

Released

River	Mean Released Catch/Angler	Median Released/Angler	N	95% CI MoE (%)	90% CI MoE (%)	80% CI MoE (%)
Exploits R.	2.20	0	249	43.8	35.7	27.1
Humber R.	0.80	0	200	59.8	48.8	37.0
Gander R.	0.54	0	115	73.5	60.0	45.5
Salmon R.	0.84	0	57	84.5	68.9	52.3
Southwest/Bottom Bk.	0.75	0	55	112.8	92.0	69.8
Gambo R.	1.30	0	50	118.2	96.5	73.2
Harry's R.	1.31	0	49	117.1	95.5	72.5
Salmonier R.	1.00	0	48	120.1	98.0	74.4
Grand Codroy R.	1.94	0	36	124.8	101.8	77.3
River of Ponds	0.92	0	26	142.2	116.0	88.1

Effort

River	Mean Effort Catch/Angler	Median Effort/Angler	N	95% CI MoE (%)	90% CI MoE (%)	80% CI MoE (%)
Exploits R.	9.02	4	249	22.2	18.1	13.8
Humber R.	8.00	4	200	26.6	21.7	16.5
Gander R.	5.58	3	115	36.1	29.5	22.4
Salmon R.	5.35	3	57	53.7	43.8	33.3
Southwest/Bottom Bk.	4.35	3	55	56.6	46.2	35.1
Gambo R.	7.40	4.5	50	60.6	49.4	37.5
Harry's R.	7.06	4	49	61.3	50.0	38.0
Salmonier R.	4.88	2.5	48	68.6	56.0	42.5
Grand Codroy R.	5.81	3	36	74.1	60.4	45.9
River of Ponds	8.04	3.5	26	82.0	66.9	50.8



1994 NEWFOUNDLAND & LABRADOR

Inland Fishing License (Individual) 00000

RESIDENT (SALMON)

Please print One Letter or Number Per Block. Do Not Alter or Deface

SURNAME | FIRST NAME AND INITIAL | SEX

MAILING ADDRESS

POSTAL CODE

e-mail address

DATE OF ISSUING (DD/MM/YY)

TELEPHONE - -

ID# - - -

VENDOR

WILDLIFE ID #

IF YOU DID NOT FISH PLEASE CHECK ☐

IMPORTANT: Record all days fished even if you had no catch.

(Return Copy)

Licence Number 00000

1994 Date		River	Zone	Hours Fished	Small		Large	
Day	Mo				Retained	Released	Retained	Released

Figure 1. Example of a recreational salmon licence. Top image is the vendors slip and the bottom image is the angler log.

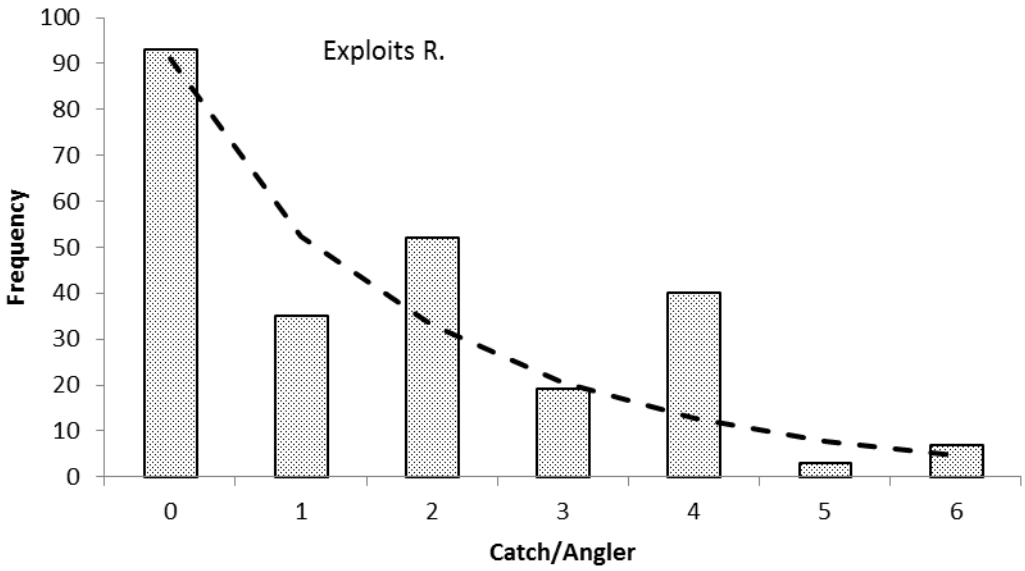


Figure 2. Histogram of the frequency of different catches per angler (shaded bars) and a fitted negative binominal curve (dashed line).

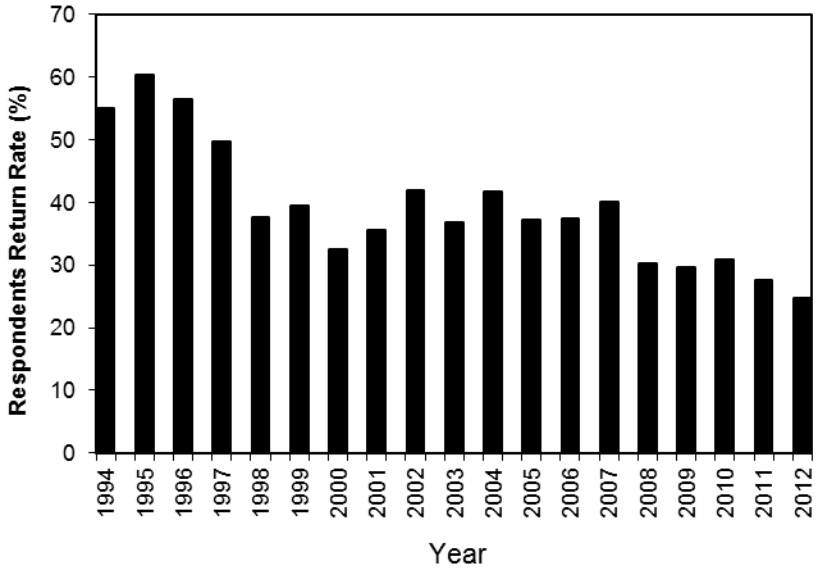


Figure 3. Black bars represent the annual proportion of the licences sold that are returned by Respondents either voluntarily or following one or more prompts.

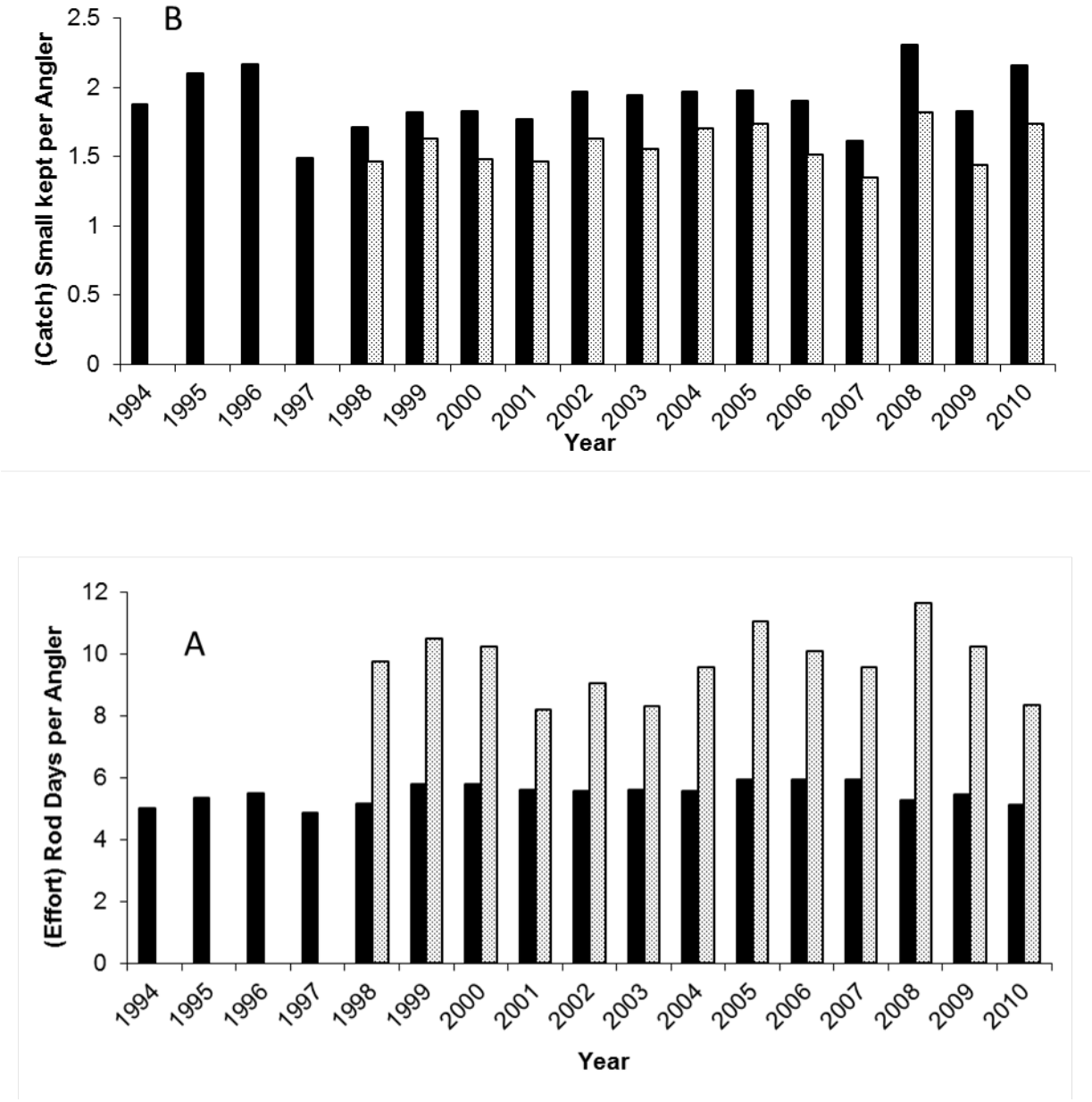


Figure 4. Comparison of the angling effort (A) and catch (B) reported by Respondents (solid bars) and Non-respondents (dotted bars) from 1994 to 2010.

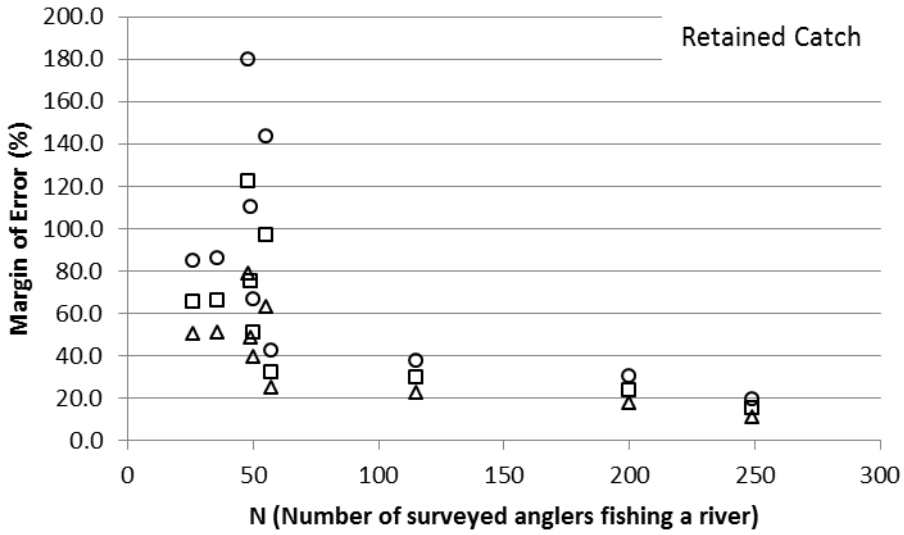


Figure 5. Relationship between the number of anglers in the phone survey reporting fishing ten of the more popular rivers in the province and the associated margin of error for the 95% (circles), 90% (squares), and 80% (triangles) confidence intervals for mean retained catch.

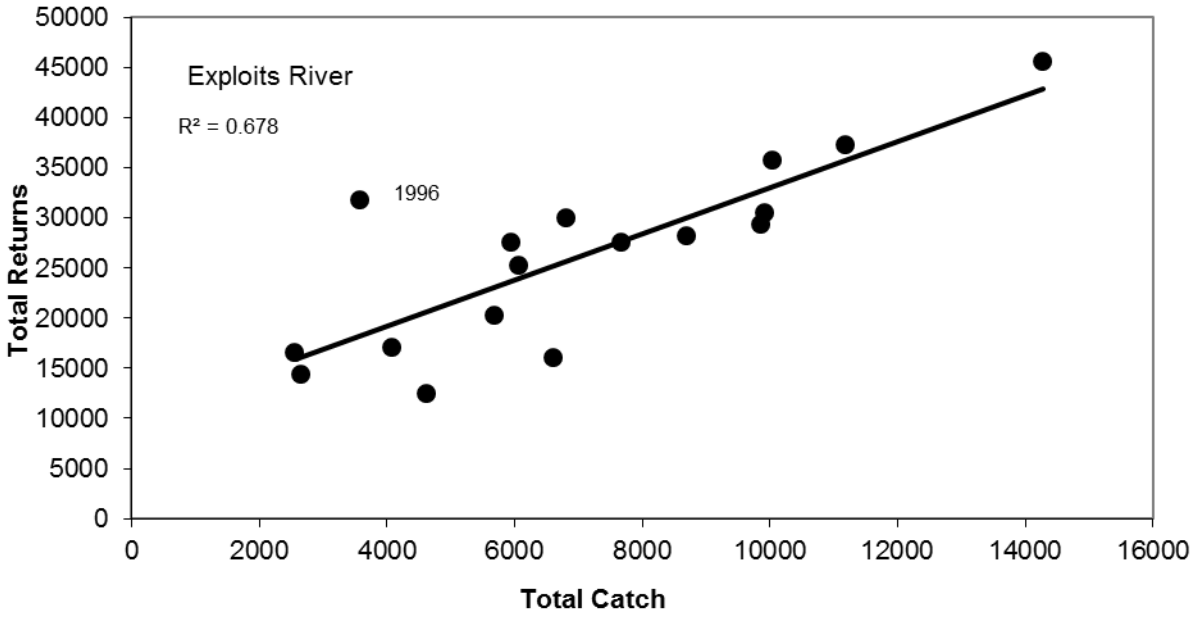


Figure 6. Relationship between total annual catch (retained + released) from the licence stub program and total returns to Exploits River. Solid line is the least squares regression line.