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INTERPRETING ATLANTIC SALMON (SALMO SALAR) ANGLING STATISTICS ON THE MARGAREE RIVER, NOVA SCOTIA

by

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ABSTRACT

From 1987 to 1989, access-point creel surveys, roving creel surveys, mark-recapture experiments, and volunteer angler logbook programs were conducted on the Margaree River, Nova Scotia, Canada to resolve the discrepancy between two methods used to collect Atlantic salmon (Salmo salar) angling statistics. Catches estimated from angling license returns were 3-6 times higher than those by fishery officers during river patrols. This discrepancy was greatest for large salmon (≥ 63 cm), which if hooked must be released and made it difficult to interpret hook and release values relative to historical kill records. Creel surveys indicated that fishery officers consistently underestimated numbers of fish killed by a factor of 1.1 to 1.5, hook and release catches, however, were underestimated in some years but overestimated in others. Creel surveys also agreed closely with angling exploitation rates predicted from the mark-recapture experiments, but license returns, fishery officer, and logbook estimates did not. These results demonstrate that small well-designed creel surveys and mark-recapture experiments improve interpretation of data from large surveys.

RESUME

De 1987 à 1989, des enquêtes directes - itinérantes et aux points d'accès - des expériences de marquage-recapture, et des programmes de relevés volontaires de prises par les pêcheurs sportifs de la rivière Margaree (Nouvelle-Ecosse) ont été réalisés afin de résoudre l'écart entre les statistiques de pêche sportive du saumon de l'Atlantique (Salmo salar) obtenues selon deux méthodes. En effet, les estimations de prises fondées sur les permis de pêche retournés étaient de trois à six fois plus élevées que celles établies par les agents des pêches durant leurs patrouilles de la rivière. Cet écart était encore plus grand dans le cas du gros saumon (≥ 63 cm), qui s'il est pris doit être relâché, et rendait difficile l'interprétation des données de capture-remise à l'eau par rapport aux taux de mortalité historique. Les enquêtes directes ont révélé que les agents de pêches ont constamment sous-estimé, par un facteur de 1,1 à 1,5, le nombre de poissons tués, tandis que les captures-remises à l'eau étaient sous-estimées pour certaines années mais surestimées pour d'autres. Les résultats de ces enquêtes correspondaient étroitement aux prévisions de taux d'exploitation de la pêche sportive fondées sur les expériences de marquage-recapture. Tel n'était pas le cas cependant des données provenant des permis retournés, de celles des agents des pêches et des estimations fondées sur les relevés volontaires. Voilà qui démontre que les petites enquêtes directes bien conçues et les expériences de marquage-recapture améliorent l'interprétation des données provenant d'enquête de grande envergure.

INTRODUCTION

Angling catch and effort data combined with angling exploitation rates are often the only methods for determining Atlantic salmon (Salmo salar) spawning stock size in the larger rivers of Atlantic Canada and Europe (Chadwick 1985; Cowx et al. 1986). Using angling catch to calculate spawners requires that catches accurately represent the fishery and not reflect a relative index of catch. Hence, proper interpretations of angling statistics are essential for assessing stock status and providing biological advice to fisheries managers.

Recently, interpreting angling statistics for the Margaree River, Nova Scotia, has been difficult because of a discrepancy between historical catch records, collected since 1947, by field fisheries officers (Chaput and Claytor 1988) and catches estimated from license card returns which anglers were required to return beginning in 1983 (O'Neil et al. 1986). Catches estimated from license returns have generally been 2-5 times higher than those made by fisheries officers (Claytor and Chaput 1988). In 1984, a regulation requiring that all large salmon (≥ 63 cm) be released made it difficult to interpret new hook and release estimates relative to the historical kill records collected by fisheries officers. Because these methodological and in-river regulatory changes also coincided with a closure of local Atlantic salmon commercial fisheries, it was not clear whether the differences observed in catch estimates resulted from changes in methodology, management, or both. Resolving these difficulties is important for assessing the status of Gulf Nova Scotia salmon stocks because 95% of the eggs deposited in these rivers come from salmon >63 cm (Claytor and Chadwick 1985).

In 1987, three programs were initiated on the Margaree River, Nova Scotia, to resolve this discrepancy and enable us to interpret hook and release catches relative to historical kill records. These programs were first, access-point

(1987 - 1988) and roving (1989) creel surveys, second, a group of anglers were requested to keep a daily logbook of their catch, effort, and releases, and third, mark-recapture experiments were used to provide an independent estimate of population size. In addition, tag returns from these experiments were used to determine exploitation rates based on the catch estimates derived from fisheries officers, license returns, and creel surveys.

This case history demonstrates how an integrated approach including small appropriately designed surveys can be used to interpret catch and effort estimates obtained from larger more general surveys. This integrated approach is important because none of these programs applied in isolation are suitable for estimating catch and determining numbers of spawners.

MATERIALS AND METHODS

Study Area

Eighteen rivers support Atlantic salmon recreational fisheries in the Nova Scotia, Gulf of St. Lawrence area. Of these rivers about 75% of the catch occurs on the Margaree River (O'Neil et al. 1986) (Fig. 1). This study concentrates on the Margaree River with data supplemented from three other Gulf Nova Scotia rivers (Fig. 1).

The Margaree River has two branches, the Northeast and Southwest. These two branches meet at Margaree Forks to form the Main Margaree which flows into the Gulf of St. Lawrence. Most of the salmon angling occurs in the Main and Northeast Margaree Rivers. There are approximately 60 angling pools on the river. The principal angling pool is Forks Pool which has accounted for 7 to 40% of the salmon caught in the river since 1947 (Chaput and Claytor 1988) (Fig. 2).

Margaree River salmon stocks are composed of two runs: the summer run enters the river from May to the end of August, and the fall run, after September 1 (Claytor and Chaput 1988).

Catch Estimates

Catches were estimated by two types of procedures; those which depended exclusively or primarily on angler reports, where anglers provided catch and effort data sometime after fishing events, and those using exclusively on-site surveys to obtain catch and effort data while fishing was in progress.

Angler Reports

Department of Fisheries and Oceans (DFO) data were collected during fishery officer enforcement patrols of the river and from information volunteered by anglers to fisheries officers. For example, during a patrol an angler may mention fish caught in a previous week, these fish would be recorded by the officer. Thus, not all fish recorded were seen by officers and patrols were not randomly or systematically scheduled. Consequently there was no method for estimating catch and effort when there were no patrols. Hence, these data depend primarily but not exclusively on angler reports to estimate catch. Data recorded by officers, since 1947, included date angled, location of capture (pool), and size, i.e. 1SW (< 63 cm) or MSW (≥ 63 cm) (Chaput and Claytor 1988).

Since 1983, catches have also been estimated from anglers returning report cards attached to Nova Scotia salmon licenses (LIC). Anglers were required to indicate number of 1SW salmon killed by date and river. Salmon released, whether 1SW or MSW were indicated by river but not date caught. Hence, this method depends exclusively on angler reports.

Because MSW salmon releases were not reported by date, fish in the fall were estimated by the proportion of MSW salmon estimated as released by DFO in summer and fall periods. From 1986-1989, the proportion of fall 1SW salmon estimated by LIC has exceeded DFO. If this trend also applies to MSW salmon estimates, then LIC fall MSW release estimates are likely to be underestimates (Appendix 1).

LIC report cards were generally returned after all angling seasons in Nova Scotia closed, October 31. Some cards were returned without prompting, but up to three reminder letters were sent to non-respondents, 1983-1987. Return rate on cards has exceeded 90% from 1983-1987. In 1988 and 1989, only a single reminder was sent and response rates were 75%. Procedures for estimating catch and effort from non-respondents is summarized in O'Neil et al. (1986).

Creel Methods - 1987, 1988

An access-point creel survey (CREEL) (Malvestuto 1983) was conducted at Forks Pool on the Margaree River from September 1-October 15, 1987 and from June 1 - October 15, 1988 to provide a catch estimate which could be used to adjust DFO estimates. In both years the angling season extended from June 1-October 15. Creel periods in both years were stratified into AM (0600-1330) and PM (1330-2100) and weekday and weekend (including holidays) periods. In 1987 75% of the available weekdays and 50% of the weekends were sampled. Because of the distribution of effort determined in 1987, this coverage was changed to 67% of available weekdays and weekends in 1988. Specific days and time periods sampled were selected using a random number table.

During the creel periods anglers were interviewed as they left the pool to obtain the time they started and completed fishing, numbers of 1SW salmon killed, and 1SW and MSW salmon hooked and released, as well as method of release. Hence, this procedure was exclusively an on-site survey method.

The release methods were defined as:

1. Fish handled (HAND), fish was handled by angler and hook removed by hand;
2. Cut line (CUT), fish was not handled but leader was intentionally cut or broken by angler;
3. Lost (LOST), fish took fly, but dislodged hook or broke line before it could be intentionally released.

MSW salmon released by HAND and CUT methods were considered to be equivalent to a fish that could have been killed had there not been a requirement to release them.

The observed catch and effort data from each stratum were used to estimate total catch and effort at Forks Pool for the dates surveyed in the following manner. Total effort at Forks Pool was estimated by calculating mean effort in Hours/Day and multiplying by the number of available days in each stratum. These estimates of effort were then multiplied by observed catch/effort to determine estimated catch in each stratum. Estimated catches were divided into 1SW and MSW salmon based on the proportion observed within each stratum by the creel clerk. The estimated catches and efforts were then summed to determine the overall estimated catch/effort (Appendix 2).

Creel Methods - 1989

In 1989 a roving (CREEL) creel survey (Malvestuto, 1983) was conducted to estimate angling catch and effort for the entire river during the fall season, September 1 to October 15. The river was divided into three sections (Fig. 2). Section A was from East Margaree Bridge to Brook pool; Section B from Sheppards Rock to Ingram Bridge; and Section C from Hatchery to Cemetery pool.

Creel periods were stratified into AM (0600 - 1330) and PM (1330 - 2100) and weekday and weekend (including holidays) periods. Each section was randomly assigned 10 days, so that 11/16 (69%) weekends and 19/29 (66%) weekdays were sampled (Appendix 3).

The creel clerk travelled each section counting the anglers at each pool and interviewing 1/5 anglers at each pool (pool counts). These pool counts began at the most downstream or upstream pool as determined in advance by coin toss. Either before or after the counting procedure, determined by coin toss, the clerk would go to an interview pool within each section and interview anglers leaving the pool to obtain information regarding completed angling trips. For Section A the interview pool was either Seal or Forks pool, for Section B Red Bank, and for Section C either Hatchery or Ross Bridge pool. For sections where there was a choice of pools, a coin toss determined which pool was visited (Appendix 3). River sections were selected because they could be covered during a single eight hour shift by one creel clerk. Equal effort was assigned because it was not known what proportion should be applied to each section.

Analysis

Catch and effort for each stratum was estimated from data collected during pool counts and interviews (Appendix 4). These stratum estimates were then expanded to daily river catch and effort and then seasonal catch and effort (Malvestuto et al. 1978, Appendix 5).

Volunteer Angling Logbooks

A subsample of anglers fishing in the Margaree River was requested to keep logbooks of the start and finish times for each fishing trip, pools fished, numbers of fish killed, hooked and released, and method of release. Hence, these logbooks depend exclusively on angler reports. In 1987, eleven anglers contacted through the local angling association, participated out of twenty contacted.

In 1988, 32 out of 60 anglers contacted participated. Anglers additional to those participating in 1987 were chosen randomly from groups fishing < 10 rod-days, 10 - 29 rod-days and > 29 rod-days as indicated by license returns in 1987. Anglers were selected so that 20 from each effort category were contacted, including those participating in 1987.

In 1989, logbook anglers were also contacted from three other Gulf Nova Scotia Rivers, West River, Antigonish, East River, Pictou, and River Philip (Fig. 1) to supplement the findings from the Margaree River program. Twenty anglers from each river were contacted from a list of names supplied by local fisheries officers. Twenty-six anglers participated from these three rivers.

In 1989, data were compiled only for anglers completing both voluntary logbooks and license return cards, hence sample sizes used are slightly less than the number of anglers participating.

Fall population estimate-Exploitation rate

In 1987, a tagging project was initiated on the Margaree River to estimate exploitation rate. In that year, one tagging net was operated in the estuary for one week each month, from June to October. These data provided information on MSW:1SW ratios during the summer and fall runs but could not be used to estimate population size.

In 1988 and 1989, this tagging program was changed so that exploitation rate and population size could be estimated for the fall run. To achieve this objective, numbers of salmon returning to the Margaree River during the fall, September 1 - October 15, 1988 were estimated by mark-recapture techniques. Two trapnets located in the estuary portion of the river 1.5 km apart were used in this experiment (Fig. 2). A numbered carlin tag was attached to all fish captured in each trap with the exception of weak fish.

Population estimates of salmon returning to the Margaree River were obtained using Schaefer's method for stratified populations and Peterson's non-stratified method (Ricker 1975) based on fish tagged in the lower net and tag recoveries and catch in the upper net. Because tag returns from 1SW and MSW salmon were not sufficient for separate estimates, returns from these groups were combined. Numbers of 1SW and MSW salmon were then determined using the proportion of each age group caught during the entire season in both trapnets.

Tagging and recovery periods were divided into two equal strata covering the time period both nets were fishing; smaller strata were unsuitable because they led to periods with zero recoveries. In 1988, the period from September 2 - October 15 was divided in half producing two tagging periods from September 2 - September 23 and September 24 - October 14. Recovery periods were lagged one day September 3 - September 24 and September 25 - October 15 because one day was the minimum time period between tagging and recovery from these fishing methods (Claytor and Chaput 1988). In 1989, the period September 5 - October 16 was divided into two equal time periods, September 5 - 25 and September 26 - October 16. Recovery periods were not lagged because fish were marked and recaptured on the same day in 1989.

Removal of tags from those available to be recovered may occur from tag loss, mortality, or fish leaving the river system. The estimate of tags removed from those available between the lower trap to the upper trap was 15%. The tag loss rate from lower net to the angling fishery was estimated to be 26%. The non-reporting rate of tags by anglers was estimated at 33% (Appendix 6). Detailed descriptions of the nets and their locations as well as the calculations of tag removal, non-reporting rates and population estimates may be found in Claytor and Chaput (1988). The only change from 1988 regarding nets was that the upper trapnet was changed from one in which the leader ran perpendicular from shore to one which resembled the lower net. That is there were two leaders, one angled from shore and the other into the channel, leading to the trapnet as they would for a partial counting fence.

RESULTS

Catch estimates

Estimates of 1SW salmon killed and MSW salmon released were consistently higher by LIC than DFO from 1987 to 1989. This difference was 1.8 to 2.3 times for 1SW salmon killed but much higher for MSW salmon released, 3.5 - 6.0 (Table 1).

CREEL estimates at Forks Pool (1987 - 1988) and for the river (1989) indicated that DFO consistently underestimated numbers of 1SW salmon killed by a factor of 1.1 to 1.5 (Table 2). In contrast, CREEL estimates indicated that DFO MSW salmon release estimates were not reliable. For example, DFO underestimated MSW releases in 1987 and 1989, but overestimated them in 1988 (Table 2). However, within 1988, the correction factor and overestimate were consistent between summer and fall samples (Table 2).

Angler reports on logbooks and licenses were also consistent for salmon that were killed but unreliable for those released. Numbers of 1SW salmon killed differed by +10 to -13% between these two methods by year and river (Table 3). However, MSW salmon release reports between logbooks and licenses differed by +30 to -18 by year and river (Table 3). Hence, killed fish were reported with more consistency than released fish, even when specific definitions of release methods were supplied to the anglers.

Evaluating catch estimates

Fall population estimates based on Schaefer and Peterson estimates were similar to each other, less than 10% difference (Table 4, Appendix 7). Applying the proportions of 1SW and MSW salmon caught in the traps to Schaefer estimates provided 1SW and MSW estimates for fall 1988 and 1989 (Table 5).

Applying a 26% tag loss rate to the angling fishery and a 33% non-reporting rate to tags returned from non-logbook anglers indicated that exploitation rate was 10 to 16% for 1SW salmon and 7 to 8% for MSW salmon returning during the fall, 1988 and 1989 (Table 6).

Comparisons of exploitation rates calculated from tag returns and angling catches divided by the population estimate were possible only for 1988 and 1989, the years in which both exploitation rate and population size were estimated (Table 7). Creel exploitation rates were more similar to those estimated by tag returns than LIC or DFO estimates for 1SW and MSW salmon. LIC and DFO each produced estimates which were > 100% tag estimates (Table 8). Hence, results from the two types of on-site surveys (mark-recapture, tag returns and CREEL) tend to support one another, while angler reports differ from each other and the experimental on-site surveys.

Examining MSW:1SW ratios in the various sampling regimes provided a method that was independent of exploitation rate and catch estimates for determining which data collection methods were most representative of the fishery. MSW:1SW ratios in trap, CREEL, and tags were similar for 1987 - 1989 (Table 9). However, these ratios in logbooks, LIC, and DFO differed considerably from each other and on-site surveys (Table 9). As with the analysis of exploitation rates and population estimates on-site survey methods tend to produce similar results, while angler report data varied among methods.

DISCUSSION

Because 95% of the egg deposition in the Margaree River comes from MSW salmon (Claytor and Chadwick 1985) evaluating whether or not spawning requirements are met and subsequently, appropriate harvest levels, requires determining the number of MSW salmon returning to the river. To determine these numbers from angling catch we must back-calculate using an appropriate exploitation rate. Because of the discrepancy in the catch estimates for this river (Table 1) and the uncertainty of their relationship to numbers of spawners, a relative index of catch and abundance is not presently suitable for assessing the status of Margaree River salmon stocks. Hence, our objectives are to determine which catch estimates, those based primarily on angler reports, (DFO, LIC) or on-site surveys (CREEL) most accurately represent the Margaree River fishery and to relate current MSW salmon release estimates to historical MSW killed records.

Neither DFO nor LIC MSW salmon release estimates accurately represented the fishery. DFO estimates were inconsistent and unreliable, while LIC consistently overestimated MSW salmon releases (Tables 7, 8). As a result, adjustments to DFO and LIC were necessary if an accurate representation of the fishery was to be obtained.

Exploitation rates calculated from CREEL estimates were similar to tag return rates for MSW salmon releases and 1SW salmon killed (Tables 7, 8), suggesting that catches estimated by the creel survey accurately represented the fishery. Because the creel adjustment factor was based on a comparison of data collected by CREEL and DFO at Forks Pool, it cannot be applied to LIC estimates which were collected for the entire river. However, MSW:1SW ratios from the various surveys can be used in evaluating which sampling methods, on-site or angler reports, most accurately represent the fishery.

The trapnet sampling which occurred as part of the mark-recapture experiment was assumed to be an unbiased sample of salmon returning to the river in fall, 1988. Selectivity should have been minimal at these traps because of the small mesh used in the leaders and traps (3.5 - 7.5 cm). Therefore, angling estimates which have MSW:1SW ratios similar to those in the trap samples are likely to more accurately represent the fishery than estimates which have dissimilar ratios.

CREEL estimates have similar ratios to those in the trapnet, while angler report estimates have dissimilar ratios (Table 9, 10). Because of the similarity between exploitation rates calculated from the mark-recapture experiment, exploitation rates from CREEL estimates, and the similarity in MSW:1SW ratios we conclude that well designed on-site surveys are preferred to angler reports for estimating Atlantic salmon catches on the Margaree River.

One reason on-site creel surveys may be superior to angler reports in representing the fishery may be the difficulty in maintaining a consistent definition of released fish, even when definitions are specified. Some evidence for this inconsistency exists in the 1987 logbooks. For these reports it appeared that several anglers included lost fish as released on license cards because logbook releases plus lost fish nearly equalled LICENSE releases. This effect was in contrast to 1988 logbooks in which more fish were reported as released and lost on logbooks than on license returns (Table 3). In addition, MSW:1SW ratios for angler reported sampling regimes (DFO, LIC, LOG) do not agree with each other or those observed by on-site surveys (CREEL and trap). However, CREEL and trap MSW:1SW ratios generally correspond (Tables 9, 10), indicating trained on-site observers produce consistent results, contrary to angler reports.

While these results suggest that angler reports are not an appropriate means of estimating released fish, they may be suitable for killed fish. Similar catches are reported for LOG and LIC (Table 3) and CREEL results indicated that DFO underestimated 1SW salmon killed (Table 2) by a consistent factor. Thus, the principal difficulty in using angler reports results from their tendencies to be inconsistent and overestimate released fish.

Other studies have also found that angler reports over-estimate catch compared to partial creel surveys (Huntsman et al. 1978; Jacobson et al. 1983) and vary from the true catch by 56 to 152%, when it is known by complete counts (Baxter and Young 1953). In addition, Huntsman et al. (1978) found that logbook overestimates were proportional to the size of the catch and concluded that adjustments of angler reports were necessary for assessing stocks and comparing with other catch statistics. Although, as they suggest, provided results are consistent, angler reports are an adequate relative index of catch.

As a result, if a program's purpose is to develop a relative index of catch, angler reports may be sufficient. For example, the consistency of angler reports for 1SW salmon killed suggests that it may be possible to develop a standard correction factor, based on proportions or regressions, that could adjust for this category of catch each year. However, because angler reports tend to overestimate catch, properly designed on-site surveys conducted for sufficient years to establish the appropriate correction factors will be required.

Annual on-site surveys are likely to be the only method suitable for estimating MSW salmon releases. The inconsistency of release data collected by angler reports requires annual monitoring to interpret these estimates. For example, because we found that LIC and DFO estimates require adjustments to accurately represent the fishery, it was not possible for us to relate MSW release estimates to historical killed records for years in which creel surveys were not conducted.

Because these conclusions depend in large part on interpreting exploitation rates; two important factors should be considered. First, we expect fall tag return exploitation rates to be exceeded if an appreciable number of fish returning in the summer are not caught until fall. While this likely happens, the similarity of MSW:1SW ratios in population estimates based on trapnets and CREEL suggests this effect is negligible (Table 10). That creel estimated exploitation rates are similar to tag return rates also supports this conclusion (Tables 7, 8).

It is likely that few summer run fish are caught in the fall because fish arriving early in the year migrate further in the system than those returning in the fall. Margaree river headwaters are closed to angling and as a result, many summer run fish are not vulnerable to the fishery later in the year. LIC 1SW salmon killed estimates exceed tag return estimated exploitation rates (Tables 7, 8). This increase requires that relatively more of the 1SW salmon caught in the fall returned to the river in the summer than is suggested by creel estimates. Additional research is required to determine the percentage of fish returning in the summer that are not caught until the fall.

Second, while summer fish caught in the fall will affect the exploitation rate calculated for killed as well as released fish, multiple recaptures may inflate exploitation rates of released fish. Rainbow trout (Oncorhynchus mykiss) have been shown to have a recapture rate of 8% in a single year after release by fly fishing, while for brown trout (Salmo trutta) the recapture rate may be as high as 37% (Favro et al. 1986). The Margaree River is scheduled exclusively for fly fishing and these results may be used to determine the likelihood of multiple recaptures as a factor affecting exploitation rate.

Because adult Atlantic salmon and rainbow trout behave similarly in rivers, both prefer midstream open pools, while brown trout prefer covered pools (Favro et al. 1986), we expect the percentage of recaptures of Atlantic salmon to be more similar to rainbow than brown trout. However, even if 1988 LIC estimates are reduced by a 40% recapture rate, the resulting exploitation rate still exceeds the tag return rate by six times. Recapture rate must be much higher than expected if it is to explain the difference in exploitation rates calculated from non-adjusted LIC catches to those based on tag returns.

As long as hook-and-release regulations are in effect, only on-site creel surveys are likely to be useful for estimating MSW returns to the Margaree River by angling catch. In contrast angler reports for killed 1SW salmon appear to give results which more closely agree with on-site surveys. However, additional creel surveys are necessary to determine the consistency of 1SW fish reported killed by angler reports and will certainly be essential if MSW fish are again allowed to be killed in the recreational fishery. Once the reliability of angler reports is verified, annual creel surveys may no longer be required.

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Table 1. Atlantic salmon angling catch estimated by DFO and LIC methods for 1983 to 1988. 1SW catches represent killed fish only, while MSW catches represent released fish only. In 1984, 12 MSW salmon were killed, for a total catch of 121. LIC MSW releases were not estimated in 1983.

	1SW			MSW		
Year	DFO	LIC	LIC/DFO	DFO	LIC	LIC/DFO
1989	179	368	2.1	244	1454	6.0
1988	435	784	1.8	580	2017	3.5
1987	353	826	2.3	408	1857	4.6
1986	295	650	2.2	754	2636	3.5
1985	223	399	1.8	313	1215	3.9
1984	148	190	1.3	109 (12)	294	2.4
1983	69	100	1.5	43		

Table 2. Atlantic salmon angling catch estimated at Forks Pool (1987 - 1988) and for River (1989) by DFO and CREEL. Creel factor was calculated by dividing CREEL by DFO estimate and was used to calculate CREEL catch for 1987 and 1988, see Table 7.

		1SW			MSW		
Season		CREEL	DFO	Creel Factor	CREEL	DFO	Creel Factor
Fall	1989	57	49	1.16	311	164	1.90
Fall	1988	27	18	1.50	16	26	0.62
Summer	1988	69	54	1.28	28	43	0.65
Fall	1987	8	7	1.14	63	32	1.97

Table 3. Comparison of angler catches for Gulf Nova Scotia Atlantic salmon reported on logbooks (LOG) and License (LIC) returns.

			Rod-days		1SW killed		MSW Released		MSW Lost
Year	Location	No.	LIC	LOG	LIC	LOG	LIC	LOG	LOG
1989	Margaree	14	353	399	18	20	59	56	15
	Mainland	28	334	296	21	21	119	105	25
	Total	42	687	695	39	41	178	161	40
1988	Margaree	23	503	577	53	47	93	113	34
	Mainland	19	232	195	31	31	92	97	33
	Total	42	735	772	84	78	185	210	67
1987	Margaree	7	185	188	18	20	56	43	11
All years	Total	91	1607	1655	141	139	419	414	118

Table 4. Estimates of 1SW and MSW salmon returning to the Margaree River in fall 1988 and 1989. These estimates were made using Schaefer and Peterson methods from trapnet, N/A; not applicable. Detailed calculations shown in Appendix 5.

Year	Method	Estimate	95% Confidence Intervals
1989	Schaefer	4845	N/A
	Peterson	5088	2719 - 16189
1988	Schaefer	2797	N/A
	Peterson	2529	1405 - 7226

Table 5. A) Numbers and percentage of 1SW and MSW Atlantic salmon tagged in Margaree River during Fall 1988 and 1989, includes fish that were tagged in one net while the second net was not fishing. B) Population estimate of 1SW and MSW Atlantic salmon returning to Margaree River in Fall 1988, 1989.

A)

	Number Tagged		
Year	1SW	MSW	%MSW
1988	173	155	47%
1989	78	347	82%

B)

	Population Estimate	
Year	1SW	MSW
1989	872	3973
1988	1482	1314

Table 6. Tag returns used to calculate exploitation rates of 1SW and MSW Atlantic salmon on Margaree River, Fall 1988 and 1989. A 26% loss rate from trapnets to the angling fishery has been used to calculate adjusted tags from tags applied. Adjusted tags caught has been estimated using a 33% non-reporting rate for non-logbook anglers.

	1989 Sea-Age		1988 Sea-Age	
	1SW	MSW	1SW	MSW
Tags applied	78	347	173	155
Adjusted tags	58	257	128	115
Adjusted tags caught	6	19	21	9
Exploitation rate	10%	7%	16%	8%

Table 7. A comparison of catches and exploitation rates estimated from LIC, DFO, CREEL and tag returns (TAGS). For Fall 1988, CREEL estimates represent DFO statistics adjusted by creel factors in Table 2. Estimates of 1SW and MSW salmon returning to the river are those in Table 5. ER = CATCH / RETURNS.

		1SW				MSW			
Season	Statistic	LIC	DFO	CREEL	TAGS	LIC	DFO	CREEL	TAGS
Fall 1989	Catch	174	49	57	-	974	164	311	-
	ER	20	6	7	10	25	4	8	7
Fall 1988	Catch	310	148	222	-	988	287	178	-
	ER	21	10	15	16	75	22	14	8
				12%				8%	

Table 8. Percent difference between exploitation rate estimated from LIC, DFO and CREEL, from those estimated by tag returns.

	1SW			MSW		
Year	LIC	DFO	CREEL	LIC	DFO	CREEL
1989	100	-40	-30	257	-43	14
1988	31	-38	-6	838	175	75

Table 9. MSW:1SW ratios from on-site and angler report methods of estimating Atlantic salmon angling catch and returns to the Margaree River in 1987 and 1988. CREEL is from access-point survey at Forks Pool 1987-1988 and total river estimate by roving creel in 1989. LOG, refers to logbooks for total river. DFO is total river estimate 1987-1989.

		MSW:1SW ratios					
		On-Site			Angler Reports		
Season		Trap	Adjusted Tags Caught (Angling)	CREEL	LOG	DFO	LIC
Fall	1989	4.4:1	3.2:1	5.5:1	2.8:1	3.3:1	5.6:1
Fall	1988	0.9:1	0.4:1	0.6:1	2.9:1	1.9:1	3.2:1
Summer	1988			0.4:1	2.2:1	1.0:1	2.2:1
Total	1988			0.5:1	2.4:1	1.3:1	2.6:1
Fall	1987	6.6:1		7.9:1	4.0:1	3.4:1	6.0:1
Summer	1987	1.3:1			0.9:1	0.5:1	0.9:1
Total	1987	4.1:1			1.3:1	1.2:1	2.2:1

Table 10. Percent difference in MSW:1SW ratios in on-site and angler report survey samples from trapnet net catches from Table 9.

Season	ADJ TAGS	CREEL	LOG	DFO	LIC
Fall 89	-27	25	-36	-25	27
Fall 88	-55	-33	222	111	255
Fall 87	N/A	20	-39	-48	-9
Summer 87	N/A	N/A	-31	-62	-30
Total 87	N/A	N/A	-68	-71	-46

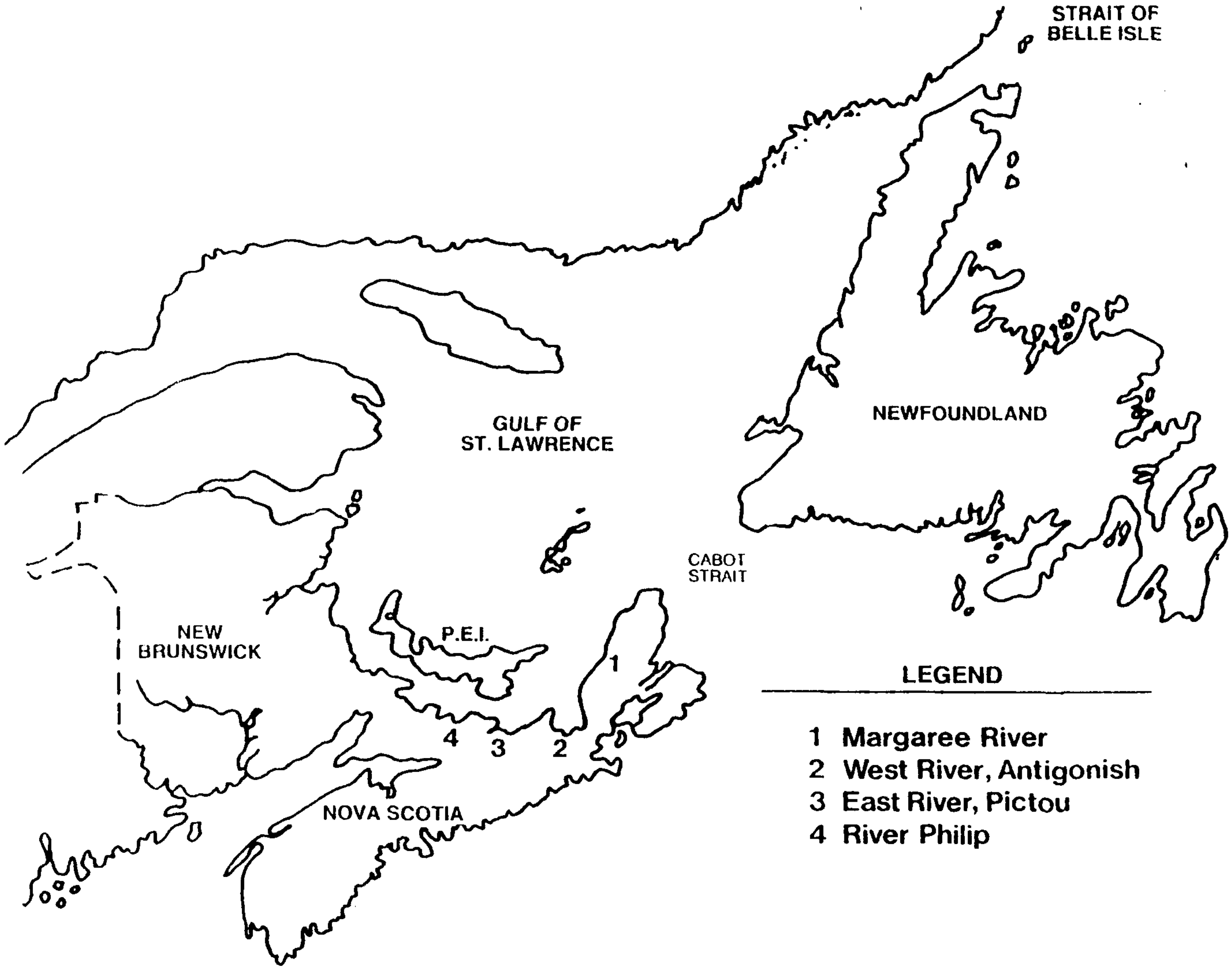

Figure 1. Gulf of St. Lawrence, Nova Scotia, Atlantic salmon rivers identified in text.

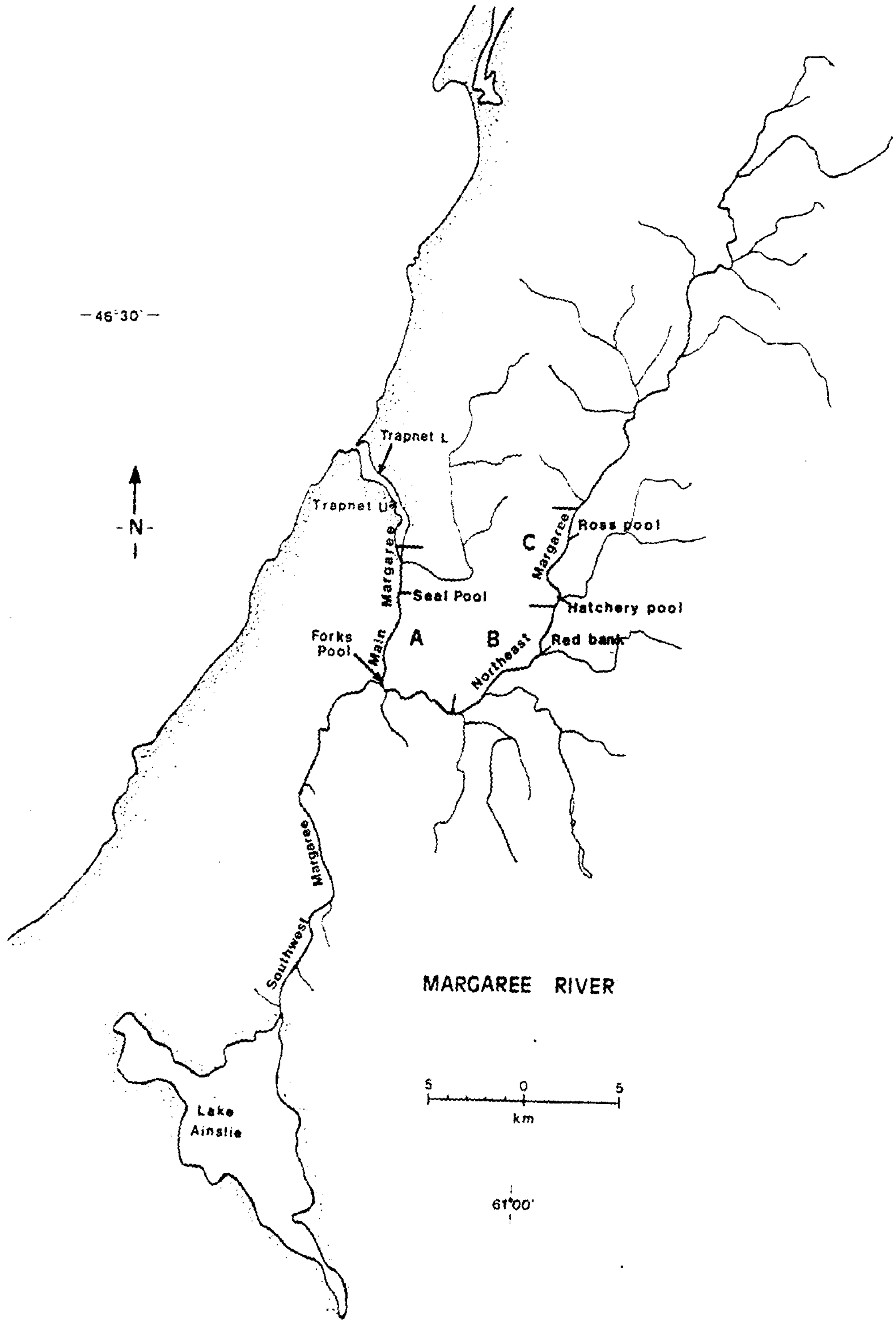

Figure 2. Data collection sites on the Margaree River identified in text.

Appendix 1. Seasonal 1SW catches according to Nova Scotia license stubs 1984-1989 and DFO sport catch. MSW LIC releases are estimated by DFO Fall percentages. Totals for LIC estimates may differ from Table 1 because of estimation procedure.

		1SW			MSW		
	Year	Summer	Fall	Percent Fall	Summer	Fall	Percent Fall
LIC	1989	194	174	47	480	974	N/A
	1988	474	310	40	1029	988	N/A
	1987	612	215	26	557	1300	N/A
	1986	396	254	39	1028	1608	N/A
	1985	243	156	39	559	656	N/A
	1984	120	68	36	65	229	N/A
DFO	1989	130	49	27	80	164	67
	1988	287	148	34	293	287	49
	1987	268	85	24	123	285	70
	1986	196	99	34	297	457	61
	1985	116	107	48	144	169	54
	1984	81	67	45	27	94	78

Appendix 2a. Method used to expand data from access point creels 1987, 1988.

1. Estimated catch for each stratum.

$$\frac{\text{Hours}}{\text{creel days}} \times \text{available days} \times \text{CUE (hours)} = \text{Catch}$$

ex. from Appendix 2b. Weekday AM, Summer

$$\frac{420}{20} \times 64 \times 0.017 = 23$$

2. Use proportions in each stratum to determine 1SW and MSW catch.

ex. Weekday AM, Summer Appendix 2c.

$$\frac{23 \times 4}{7} = 13 \text{ 1SW}$$

Appendix 2 b. Observed salmon catch, effort, and catch per unit effort for Forks Pool creel survey, 1987. RH, removed hook by hand; LO, fish was lost. K/RH, catch is sum of killed 1SW and MSW released by removing hook by hand. K/ALL, catch is sum of killed 1SW and MSW released by all methods including lost. Numbers in parentheses are standard errors.

Season	Available days	No. creel days	No. anglers interviewed	Forks Pool Creel Effort: Rod-days	Effort: Hours	Catch 1SW: Kept	Catch MSW: RH	Catch MSW: LO	CUE Fish/Rod-day: K/RH	CUE Fish/Rod-day: K/ALL	CUE Fish/Hour: K/RH	CUE Fish/Hour: K/ALL
SUMMER												
June 1 - August 31												
Weekday AM	64	20	169	169(1.07)	420(4.25)	4	3	1	0.041	0.047	0.017	0.019
PM	64	21	201	198(1.30)	488(3.90)	13	4	6	0.086	0.116	0.035	0.047
Weekend AM	28	10	95	95(2.39)	225(7.01)	3	2	0	0.053	0.053	0.022	0.022
PM	28	10	79	78(1.74)	248(8.18)	3	0	0	0.038	0.038	0.012	0.012
Total	92	61	544	540(0.73)	1380(2.55)	23	9	7	0.059	0.072	0.023	0.028
FALL												
September 1 - October 15												
Weekday AM	30	11	122	122(1.22)	329(4.25)	5	1	1	0.049	0.057	0.018	0.021
PM	30	11	80	80(1.64)	217(4.99)	1	1	1	0.025	0.038	0.009	0.014
Weekend AM	15	4	85	85(2.56)	221(3.46)	3	2	3	0.059	0.094	0.023	0.036
PM	15	5	54	54(4.72)	129(10.03)	0	1	0	0.019	0.019	0.008	0.008
TOTAL	45	31	341	341(1.29)	896(3.38)	9	5	5	0.041	0.056	0.016	0.021
1987 FALL	45	30	284	284	676	3	20	13	0.081	0.127	0.034	0.053

Appendix 2 c. Estimated effort and salmon catch at Forks Pool, June 1 - October 15, 1988 using creel data (Appendix 2b). Number in parentheses indicates 95% confidence interval.

		ESTIMATED				
				Catch		
		Effort		1SW	MSW	
Season		Rod-days	Hours	Killed	RH	LO
SUMMER						
June 1 - August 31						
Weekday	AM	541(539- 543)	1,344(1,335-1,353)	13	10	3
	PM	603(600- 606)	1,487(1,479-1,495)	40	12	18
Weekend	AM	266(261- 271)	630(614- 646)	8	6	0
	PM	221(217- 225)	694(675- 713)	8	0	0
Summer Total		1,631(1,630-1,632)	4,155(4,150-4,160)	69	28	21
FALL						
September 1 - October 15						
Weekday	AM	333(330- 336)	897(888- 906)	13	3	3
	PM	218(214- 222)	592(581- 603)	3	3	3
Weekend	AM	319(311- 327)	829(818- 840)	11	7	11
	PM	162(149- 175)	387(359- 415)	0	3	0
Fall Total		1,032(1,029-1,035)	2,705(2,698-2,712)	27	16	17
1987 FALL		887	2,086	8	63	44

Appendix 3. Roving-creel schedule for 1989. Time AM = 0600-1330, PM = 1330-2100. INT SEQ, Interview Sequence, F = pool counts done first, then interviews at index pool; L = pool counts last, interviews at index pool first.

Date		Day-type	Time	Section	INT SEQ	Direction	Index Pool
Sept	1	Weekday	PM	A	F	Ascending	Seal
	2	Weekend	PM	B	F	Ascending	Red Bank
	3	Weekend	PM	C	F	Ascending	Hatchery
	5	Weekday	PM	A	F	Descending	Forks
	6	Weekday	PM	B	F	Ascending	Red Bank
	7	Weekday	PM	C	F	Descending	Ross Bridge
	9	Weekend	AM	A	F	Descending	Seal
	10	Weekend	AM	B	L	Descending	Red Bank
	11	Weekday	PM	C	L	Ascending	Hatchery
	12	Weekday	AM	A	F	Descending	Seal
	15	Weekday	AM	C	F	Ascending	Ross Bridge
	16	Weekend	PM	B	L	Descending	Red Bank
	18	Weekday	AM	A	L	Ascending	Forks
	19	Weekday	AM	C	L	Descending	Hatchery
	21	Weekday	AM	B	F	Descending	Red Bank
	22	Weekday	AM	A	L	Ascending	Forks
	23	Weekend	AM	C	L	Descending	Ross Bridge
	24	Weekend	PM	A	F	Ascending	Forks
	26	Weekday	PM	B	L	Descending	Red Bank
	28	Weekday	AM	B	L	Ascending	Red Bank
Oct	1	Weekend	PM	C	F	Descending	Ross Bridge
	3	Weekday	AM	B	F	Descending	Red Bank
	4	Weekday	PM	C	F	Ascending	Hatchery
	5	Weekday	PM	A	L	Ascending	Seal
	6	Weekday	AM	C	L	Descending	Ross Bridge
	7	Weekend	AM	B	F	Ascending	Red Bank
	8	Weekend	PM	A	L	Descending	Forks
	12	Weekday	AM	A	F	Descending	Forks
	13	Weekday	PM	B	F	Ascending	Red Bank
	15	Weekend	AM	C	F	Ascending	Hatchery

Appendix 4 a. Roving creel effort estimation for each stratum from pool counts

1. From pool counts, ex. Appendix 4b.

   Counts X hours = count effort (CEFFORT)

2. From interview pool; ex. Appendix 4c.

$$\frac{\text{angler hours} + (\text{remaining anglers} \times \text{ave. effort})}{\text{proportion effort from pool counts}} = \text{interview effort (IEFF)}$$

where; angler hours = total effort in hours at interview pool, that is the sum of all effort for interviews conducted by creel clerk at interview pool.

remaining anglers = number of anglers remaining at interview pool when creel clerk left, but not interviewed by clerk.

ave. effort = average time (hours) spent by each angler interviewed at interview pool.

proportion effort from pool counts = number of anglers counted at interview pool during pool counts for each stratum. If no anglers were counted at a pool for a particular stratum then the next level was used. For example, if no anglers were counted at Forks Pool for Weekday AM then total weekday proportions were used.

3. Count effort + interview effort = stratum effort.

   ie. CEFFORT + IEFF = SAMPEFF

   see Appendix 4c.

Appendix 4 b. Data used to calculate count effort.

SECTION	DAY_TYPE	TIME_PER	DATE	COUNTS	HOURS	CEFFORT
A	DAY	PM	901	19	3.75	71.25
B	END	PM	902	9	4.25	38.25
C	END	PM	903	4	4.00	16.00
A	DAY	PM	905	15	3.75	56.25
B	DAY	PM	906	3	3.50	10.50
C	DAY	PM	907	5	3.50	17.50
A	END	AM	909	16	3.00	48.00
B	END	AM	910	19	2.75	52.25
C	DAY	PM	911	1	3.25	3.25
A	DAY	AM	912	12	2.75	33.00
C	DAY	AM	915	2	2.75	5.50
B	END	PM	916	17	2.75	46.75
A	DAY	AM	918	28	2.50	70.00
C	DAY	AM	919	9	3.00	27.00
B	DAY	AM	921	11	2.50	27.50
A	DAY	AM	922	23	3.00	69.00
C	END	AM	923	9	2.25	20.25
A	END	PM	924	13	2.75	35.75
B	DAY	PM	926	7	2.50	17.50
B	DAY	AM	928	11	2.50	27.50
C	END	PM	1001	11	3.50	38.50
B	DAY	AM	1003	20	3.00	60.00
C	DAY	PM	1004	15	3.25	48.75
A	DAY	PM	1005	7	2.75	19.25
C	DAY	AM	1006	12	3.00	36.00
B	END	AM	1007	9	3.00	27.00
A	END	PM	1008	21	2.75	57.75
A	DAY	AM	1012	0	3.00	0.00
B	DAY	PM	1013	15	2.75	41.25
C	END	AM	1015	3	3.50	10.50

COUNTS = number of anglers counted at pool.

HOURS = number of hours spent doing pool counts.

CEFFORT = COUNT effort, counts X hours.

Appendix 4 c. Data used to calculate interview effort.

SECTION	DAY_TYPE	TIME_PER	DATE	IHOURS	NANG	AVEFF	AHOURS	PROIND	IEFF	SAMPEFF
A	DAY	PM	901	13.2500	10	1.32500	.	0.230769	57.417	128.667
B	END	PM	902	21.5000	10	2.15000	.	0.461538	46.583	84.833
C	END	PM	903	5.5000	4	1.37500	.	0.125000	44.000	60.000
A	DAY	PM	905	0.5000	1	0.50000	.	0.090909	5.500	61.750
B	DAY	PM	906	7.5000	5	1.50000	.	0.320000	23.438	33.938
C	DAY	PM	907	2.5000	3	0.83333	.	0.400000	6.250	23.750
A	END	AM	909	17.2500	10	1.72500	.	0.625000	27.600	75.600
B	END	AM	910	10.0000	2	1.25000	7.5000	0.500000	20.000	72.250
C	DAY	PM	911	0.0000	.	.	.	0.125000	0.000	3.250
A	DAY	AM	912	42.7500	9	2.25000	22.5000	0.416667	102.600	135.600
C	DAY	AM	915	8.7500	5	1.75000	.	0.357143	24.500	30.000
B	END	PM	916	9.0000	7	1.28571	.	0.461538	19.500	66.250
A	DAY	AM	918	9.0000	1	1.00000	8.0000	0.117647	76.500	146.500
C	DAY	AM	919	.	.	.	.	0.080000	0.000	27.000
B	DAY	AM	921	8.0000	8	1.00000	.	0.404762	19.765	47.265
A	DAY	AM	922	0.0000	.	.	.	0.117647	0.000	69.000
C	END	AM	923	0.0000	.	.	.	0.100000	0.000	20.250
A	END	PM	924	12.2500	6	2.04167	.	0.235294	52.063	87.813
B	DAY	PM	926	1.5000	5	0.30000	.	0.320000	4.688	22.188
B	DAY	AM	928	0.0000	.	.	.	0.404762	0.000	27.500
C	END	PM	1001	7.0000	4	1.75000	.	0.181818	38.500	77.000
B	DAY	AM	1003	33.2143	7	2.21429	17.7143	0.404762	82.059	142.059
C	DAY	PM	1004	11.7500	7	1.67857	.	0.125000	94.000	142.750
A	DAY	PM	1005	2.7500	2	1.37500	.	0.230769	11.917	31.167
C	DAY	AM	1006	1.0000	1	1.00000	.	0.357143	2.800	38.800
B	END	AM	1007	27.8611	9	1.63889	13.1111	0.500000	55.722	82.722
A	END	PM	1008	0.0000	.	.	.	0.235294	0.000	57.750
A	DAY	AM	1012	1.5000	1	1.50000	.	0.117647	12.750	12.750
B	DAY	PM	1013	5.0000	6	0.83333	.	0.320000	15.625	56.875
C	END	AM	1015	10.4000	5	1.30000	3.9000	0.062500	166.400	176.900

IHOURS = angler hours; effort in hours at interview pool.

NANG = number of anglers interviewed to obtain IHOURS.

AVEFF = average effort spent by interviewed anglers.

AHOURS = number of hours estimated spent by anglers remaining at pool after clerk left

PROINO = proportion of effort at interview pool during pool counts (see Appendix 4a).

IEFF = interview effort; IHOURS + AHOURS.

SAMPEFF = effort during stratum, IEFF + CEFFORT.

Appendix 5 a. Calculation of Seasonal Catch and effort from roving creel survey.

1. E (Daily Effort) $= \frac{e}{p}$

   e = stratum effort (SAMPEFF)
   p = proportion of effort associated with stratum.
   a) mean stratum effort = total stratum effort / stratum sampling days
   b) proportion stratum effort = mean stratum effort / Σ mean stratum effort

2. $$CUE = \frac{GK + SR + SC}{Hours}$$; total CUE for all interviews in stratum.

3. CUE X E = total daily catch = C

4. $$\sum_{i=1}^{nn} C_{hi} / n_h = \bar{y}h$$ (mean daily catch each stratum)

   C_{hi} = estimated catch each stratum
   n_h = number of days sampled each stratum

5. Variance of mean daily catches

   $$\frac{\sum_{i=1}^{nn} C^2_{hi} - (\sum_{i=1}^{nn} C_{hi})^2 / n_h}{n_h - 1} = Vh\ (\bar{y}_h)$$

6. Calculate mean daily catch per season

   $$\sum_{n=1}^{L} N_h\ (\bar{Y}_h / N) = \bar{Y}_d$$

   N_h = total number of days within each stratum
   N = total number of days in season
   L = number of strata

7. variance of $\bar{Y}_d$

   $$V = \sum_{n=1}^{L} W^2_h V_h / N_h - \sum_{n=1}^{L} W_h V_h / N$$

   Wn = stratum weight N_h / N

8. Total harvest season $Y_s = N \bar{Y}_d$

9. Standard error total harvest

   $SE = N (\sqrt{v})$

10. 95% C.L. $Y_s \pm t_{0.05}$ SE; d.f. $= \frac{N_h - 1 + \Sigma N_h}{2}$

Same procedures for effort.

Appendix 5 b. Summary of raw data and catch and effort estimates for roving creel survey, GK, grilse (1SW) killed; SR, salmon (MSW) released by HAND and CUT.

a) Observed Creel - 1989

Section	N	Counts	Interviews	Hours	GK	SR
A	10	154	106	218	2	2
B	10	121	123	252	0	5
C	10	71	105	167	0	4
TOTAL	30	346	334	637	2	11

b) Estimated Catch and Effort

	Hours	Catch	GK	SR
TOTAL	17562	368	57	311
95% C.I.	(15475 - 19650)	(197 - 540)		

Appendix 6. Estimate of non-reporting rate and available tags lost from lower to upper trap net and lower trap net to angling fishery. Assumes logbook anglers and trap recoveries have a 100% reporting rate. Hence, the ratio of recaptures/total captures from lower to upper net and lower net to angling fishery represents the proportion of tags removed from those available to each recapture method.

Location		Recovery Location		
Tagging	Recovery	Recaptures	Captures	Ratio
Lower net	Upper net	7	133	0.053
Lower net	Anglers	3	77	0.039

Hence, 0.039 / 0.053 = 0.736, 1-0.736 = 0.264 or proportion of tags removed from lower net to anglers = 26%.

If tag removals are assumed to be related to days available then the rates of the average number of days between tagging and recapture in the angling and upper trap can be used to provide a factor for tag removal between the lower and upper traps. The average length of time between lower and upper trap was 8.7 days and 15.0 days from lower trap to anglers. Hence, 8.7/15 = 0.58; 26% X 0.58 = 15.08. Therefore the tag removal rate between lower to upper trap is 15%.

A non-reporting rate for tags was calculated using tag returns during Forks Creel periods and those returned from Forks Pool when creels were not conducted. It is assumed that tags recovered during creel/observed creel catch = total tags recovered forks pool/estimated forks catch. That is, 1/14 = X/43; X = 43/14 = 3. Two tags in total were returned. Therefore reporting rate is 2/3 or 67% and non-reporting rate is 33%.

Appendix 7. Schaefer and Peterson estimates from trapnet and angling data. A 15% tag removal factor was used to reduce tags available in trapnet estimate (M_i only).

1988

Recovery Period	TRAP Tag Period 902-923	TRAP Tag Period 924-1014	Tagged fish recovered Rj	Total fish recovered Cj	Cj/Rj
903- 924	3	0	3	60	20.0
925-1015	2	2	4	73	18.25
Tagged fish recovered Ri	5	2	7	--	----
Total fish tagged Mi	56	94	-	--	----
Mi/Ri	11.2	47.0	-	--	----

1989

Recovery Period	TRAP Tag Period 905-925	TRAP Tag Period 926-1016	Tagged fish Recovered Rj	Total fish Recovered Cj	Cj/Rj
905- 925	1	0	1	121	121
926-1016	3	2	5	90	18
Tagged fish recovered Ri	4	2	6		
Total fish tagged Mi	70	99	-	--	----
Mi/Ri	17.5	49.5	-	--	----

	Schaefer Estimate 902-923	Schaefer Estimate 924-1014	TOTAL
903- 924	672	0	672
925-1015	409	1716	2125
TOTAL	1081	1716	2797

	Schaefer Estimate 905-925	Schaefer Estimate 926-1016	TOTAL
905-925	2118	0	2118
926-1016	945	1782	2727
TOTAL	3063	1782	4845

Peterson Estimate

M = 150 151 X 134/8 = 2529
C = 133
R = 7 95% C.I. (1405-7226)

M = 167 168 X 212/7 = 5088
C = 211
R = 6 95% C.I. = (2719-16189)