Fisheries and Oceans Science | Pêches et Océans Sciences

C S A S | ***S C É S***

Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Research Document 2000/037 | **Document de recherche 2000/037**

STATUS OF THE ATLANTIC SALMON *(Salmo salar L.)* STOCK OF HUMBER RIVER, NEWFOUNDLAND, 1999

C.C. Mullins and D. Caines

Department of Fisheries and Oceans
Science Branch
1 Regent Square
Corner Brook, Newfoundland
A2H 7K6

ISSN 1480-4883
Ottawa, 2000

Canada

ABSTRACT

This is the tenth assessment of the Atlantic salmon stock of the Humber River. The results of the mark-recapture study in 1999 indicated that 27,585 (95% CI=20,779 - 37,984) small and 4,433 (95% CI=3,042 - 6,675) large salmon returned to the Humber River during the period of the study. The recapture trap used in 1999 was preferable to angling for tag recaptures because no adjustment is necessary to account for the voluntary tag-reporting rate and the catch did not have to be estimated. A double-tagging experiment indicated no tag loss for salmon recaptured in the recapture trap and by angling. This suggested that calculation methods used in previous years might have resulted in an under-estimate of tag retention rate and possibly, then, a small under-estimate of population size. The recreational fishery retained catch of small salmon was higher than in 1998 but the released catch was lower. The released catch of large salmon was higher than in 1998. Increased retention limits and removal of split season restrictions as well as increased returns may have contributed to improved angling catches. The proportion of large salmon caught in the estuary tagging traps was lower than in 1998 but equal to 1992-98 mean. Egg depositions calculated for 1999 were 201% (95% CI = 144% - 290%) of the conservation requirement. This level of egg deposition had a very high probability of occurrence based on a probability density function incorporating some of the uncertainty associated with the estimate of returns and biological parameters. Potential sources of mortality that could result in additional uncertainty in the estimate of potential egg depositions in 1999 included record low water levels, increased indication of illegal removals and reports of seals on the river. Recruits in 1999 exceeded estimates of the spawners that produced them indicating continued improvement in the stock but fluctuations in returns in recent years create some degree of uncertainty. Returns to the river in 1998 were revised based on updated angling catch data and indicated that the conservation requirement was exceeded in 1998.

RÉSUMÉ

Le présent document traite de la dixième évaluation du stock de saumon de l'Atlantique de la rivière Humber. L'étude par marquage-recapture de 1999 montre que 27 585 (IC de 95% =20 779 – 37 984) petits et 4 433 (IC de 95% = 3 042 – 6 675) grands saumons sont revenus à la rivière Humber pendant la période d'étude. Le piège utilisé en 1999 s'est avéré supérieur à l'utilisation des pêcheurs à la ligne pour la récupération des étiquettes, car il n'était pas nécessaire d'apporter de correction en fonction du taux de rapport volontaire des étiquettes ni d'estimer les captures. Une expérience par double marquage a montré l'absence de pertes d'étiquettes pour les saumons recapturés tant à l'aide du piège que par les pêcheurs. Cela porte à croire que les méthodes de calcul utilisées au cours des années antérieures pourraient avoir donné lieu à une sous-estimation du taux de rétention des étiquettes et, peut-être, à une légère sous-estimation de l'effectif de la population. Le nombre de petits saumons conservés par les pêcheurs à la ligne a été supérieur à celui de 1998, mais le nombre de poissons libérés était plus faible. Le nombre de grands saumons capturés et remis à l'eau a été supérieur à celui de 1998. L'accroissement des captures de la pêche récréative peut s'expliquer par le rehaussement des limites de rétention et l'élimination des restrictions touchant le fractionnement de la saison, auxquels s'ajoute l'accroissement des remontées. La proportion de grands saumons capturés dans les pièges de marquage en estuaire a été inférieure à celle de 1998, mais égale à la moyenne de 1992-1998. La ponte calculée de 1999 correspond à 201 % (IC de 95% = 144% - 290%) des besoins de conservation. Comme l'indique une fonction de densité de probabilité tenant compte d'une partie de l'incertitude liée à l'estimation des remontées et des paramètres biologiques, la probabilité d'un tel niveau de ponte est très élevée. Les causes de mortalité qui pourraient accroître l'incertitude de l'estimation de la ponte en 1999 comprennent des niveaux d'étiage records, des indices accrus de récolte illégale et le signalement de phoques dans la rivière. Les recrues de 1999 sont supérieures aux estimations des géniteurs correspondants ce qui indique une amélioration continue du stock, mais les fluctuations affectant les remontées des dernières années sont sources d'une certaine incertitude. Les remontées de 1998 ont été révisées en fonction des données mises à jour de la pêche à la ligne et indiquent que les besoins de conservation ont été dépassés en 1998.

INTRODUCTION

This is the tenth assessment of the status of the Atlantic salmon (*Salmo salar* L.) stock of the Humber River since 1990. In 1990 and 1991, prior to the implementation of the commercial salmon fishery moratorium and effort controls in the recreational salmon fishery in 1992, the stock achieved 60% and 27%, respectively of its conservation requirement (Chaput and Mullins MS 1991, 1992). Since 1992, with the exception of 1994, the Humber River salmon stock has shown signs of improvement. The low population size in 1994 could be attributed to extremely low spawning escapements in 1989 as suggested by retrospective analysis of salmon angling data (Chaput and Mullins, MS 1992). Low marine survival as well as uncertainty in angling data used to estimate returns to the river could be other factors. Commercial and recreational salmon fishery management measures implemented in Newfoundland and Labrador since 1978 that would have affected harvests of Humber River salmon are given in Table 1.

The Humber River is located at the northern limit of Salmon Fishing Area (SFA) 13 and flows into the Humber Arm of the Bay of Islands at latitude 48° 57' N and longitude 57° 53' W (Fig. 1). It is the second largest river system in Newfoundland and the largest on the western part of the island. Its drainage area of 7,679 km^2 represents 95% of the drainage area of the Bay of Islands and 57% of SFA 13. The total length of all tributaries in the system is 2,450 km. Complete obstructions to anadromous Atlantic salmon occur at Main Falls (Fig. 2) which is 112.6 km from the river mouth and at Junction Brook. Junction Brook once flowed into the Humber River at Deer Lake but was diverted for hydroelectric development in 1925, resulting in the loss of anadromous salmon habitat on the Grand Lake system (Porter et al., MS 1974) (see Fig. 2). No fish passage facility was provided for fish to bypass the diversion.

Recreational salmon fishery statistics (O'Connell et al. MS 1998) indicate that the Humber River produced an average total catch of approximately 7,000 small and large salmon in 1994-97. This represents about 50% of the total catch in SFA 13 and is the highest catch of any river in Newfoundland and Labrador.

The present assessment provides an estimate of the number of adult Atlantic salmon returning to the Humber River in 1999 based on independent mark-recapture studies. The status of the resource is assessed relative to established conservation requirements with consideration for the associated uncertainties. The methodology closely follows that of previous assessments (Chaput and Mullins, MS 1991; Chaput and Mullins, MS 1992; Mullins and Chaput, MS 1993; Mullins and Chaput, MS 1995; Mullins and Reddin, MS 1995; Mullins and Reddin, MS 1996; Mullins et al., MS 1997; Mullins and Caines, MS 1998; Mullins and Caines, MS 1999).

MATERIALS AND METHODS

RECREATIONAL SALMON FISHERY

Recreational salmon fishery catches of small (<63 cm) and large (≥63 cm) salmon used to estimate returns and spawning escapements of salmon on the Humber River in 1998 and 1999 were based on the voluntary licence stub return system (O'Connell et al., MS 1998). The catches used prior to 1998 were based on angler creel surveys (Mullins and Reddin, MS 1995; Mullins et al. MS 1997; Mullins and Caines, MS 1998; Mullins and Caines, MS 1999). Catches of small salmon estimated from the licence stub returns were within 10% of those based on creel surveys in 1994-97 (Mullins and Caines, MS 1999).

Recreational salmon fishery statistics (catches and effort of small and large salmon) collected by DFO prior to 1997 were based on observations and estimates of catch and effort recorded by river guardians and fisheries officers (Mullins and Claytor, MS 1989 and Mullins et al., MS 1989). These statistics were not used to estimate returns to the river because of their high reliance on estimated as opposed to actual observed catches. The portion of the catch and effort estimated, as opposed to actually observed by this method, increased since 1992 (Mullins and Reddin, MS 1996). Angler creel surveys conducted at Big Falls in 1990-96 indicated that actual catches were often as much as twice as high as indicated by these statistics (Mullins and Chaput, MS 1995; Mullins and Chaput, MS 1993; Chaput et al., MS 1992). It is cautioned that the data from the most recent years is only indirectly comparable with that from years prior to 1992. All recreational salmon fishery statistics from this method and those based on the licence stub return system are given in Appendix 1.

Recreational fishery management measures that were in place on the Humber River during the period of assessment and would probably have affected catches and effort are given in Table 1.

MARKING

Small and large salmon returning to the Humber River in June to August 1999 were captured at two tagging traps operated in the estuary (Fig. 1). These salmon were marked with one or two Carlin tags depending on the total number of salmon caught and the time available for tagging. One tag was applied just under the anterior end of the dorsal fin and the second was applied immediately posterior to it. Tags were applied using a double stainless steel wire attachment. Injured salmon were not tagged. All salmon captured in the two traps were measured (fork length 0.1 cm), sexed externally and scale sampled.

The tagging traps were located approximately 1.5 km apart with the Lower tagging trap farther out in the estuary than the Upper trap (Fig. 1). The location of the

Lower trap was the same as in previous studies since 1990. The location of the Upper trap, with the exception of 1994 when this trap was located approximately 10 km farther upstream at Boom Siding, has been the same since 1993. The design of the traps and the method of installation were identical to that used in previous assessments. Two additional tagging traps were operated in 1998 - one near the Lower and one near the Upper location. This was to increase the number of tags applied as it was expected that new restrictions in the recreational fishery in 1998 might result in fewer recaptures by anglers. Catches in these additional traps were low in 1998. With the restrictions removed in 1999, the additional traps were not operated.

Daily catches in the two tagging traps were summarized by standardized weeks.

Standardized Week	Time Period
22	May 28 – June 3
23	June 4 –10
24	June 11 – 17
25	June 18 – 24
26	June 25 – July 1
27	July 2 – 8
28	July 9 – 15
29	July 16 – 22
30	July 23 – 29
31	July 30 – August 5
32	August 6 – 12
33	August 13 – 19
34	August 20 to 26
35	August 27 – Sept. 2
36	Sept. 3 – 9

TAG RETENTION

The number of tagged salmon available for recapture (M) was determined by adjusting the number of tags applied (M_a) by the tag retention rate according to the formula:

$$\mathbf{M = M_a \times Retention\ Rate}$$

Where:

$$\mathbf{Tag\ Retention\ Rate = 1.0 - Tag\ Loss\ Rate}$$

The tag-loss rate was investigated by examination of recaptured salmon for incidence of missing tags. The proportion of double-tagged salmon that were recaptured with only one tag remaining was used to represent the tag-loss rate.

In previous assessments, the tag loss rate derived for the Margaree River, Nova Scotia of 0.009 (95% CI=0.006-0.011) tags per day at large was used (Chaput et al., MS 1993). This technique was adopted because the method of tag application was similar to that used for the Humber River and it was assumed that the tag loss rates would also be similar. The median of the number of days at large for salmon recaptured by angling was used to represent the number of days at large in the calculation. The median was determined according to Sokal and Rohlf (1969).

RECAPTURES

Two recapture methods were used in 1999:

a. Recapture Trap

A recapture trap was operated approximately 50 km upstream from the estuary (Fig. 1). The trap was similar in design to the two tagging traps. The trap was anchored on pools to keep it in fishing order against the current. It was checked at least once per day, usually about one hour after sunrise. Captured salmon were sized as small or large based on a visual reference attached to the side of the trap. Untagged salmon were counted and released. Tagged salmon, with few exceptions, were dipped and held underwater while the tag number was recorded and then released. Tagged salmon that were not dipped were apportioned as tagged in 1999 or tagged in previous years based on the relative proportions observed in the tagged salmon that were dipped.

The rate of recapture of tagged small and large salmon in the recapture trap was calculated as:

$$R_{obs} / M$$

Where:
R_{obs} = Number of small salmon recaptures observed in the recapture trap

b. Angling

A reward of $10.00 was paid for each tag returned voluntarily by anglers. The number of tags returned was adjusted to account for unreported tags. The mean voluntary tag reporting rate in 1992-98 was estimated at 0.6264 (95% CI=0.5275-0.7253) based on the number of tags observed by creel survey clerks that were actually returned voluntarily by anglers (Mullins and Caines, MS 1999). This estimate of reporting rate is supported in a study by Zale and Bain (1994) who reported that, under simulated conditions, 64-67% of anglers voluntarily returned tags for a reward.

The rate of recapture by angling or the angling exploitation rate for retained small salmon was calculated as:

$$(R_v / 0.6264) / M$$

Where:
R_v = Number of small salmon (retained) recaptures reported voluntarily by anglers

The 95% confidence interval around the estimate of voluntary tag reporting rate by anglers was derived by a simulation technique. Each parameter was recalculated 5000 times by sampling at random from a uniform distribution dictated by the available data. The values corresponding to the 2.5^{th} and 97.5^{th} percentiles in the bootstrapped frequency distribution for each parameter were used as the lower and upper confidence limits, respectively. This technique has been described in detail by Diaconis and Efron (1983) and Efron and Tibshirani (1986). Formulas and parameters estimated using this technique are given in Table 2.

TOTAL RETURNS AND SPAWNING ESCAPEMENTS

a. Small Salmon Returns

Small salmon returns to the river (N_{sm}) were determined based on adjusted marks and recaptures and the catch of small salmon according to the Petersen (Single Census uncorrected) method (Ricker, 1975):

$$N_{sm} = C / er$$

Where:
C = Catch of small in the recapture trap or by angling (retained only)
er = Recapture rate in the recapture trap or by angling

The assumptions required for the application of this formula are:

1. Negligible immigration and emigration within the population.
2. Marks are not lost.
3. Marked and unmarked fish have the same mortality.
4. All marks are recognized and reported.
5. Random mixing of marked and unmarked fish.
6. Marked and unmarked fish are equally vulnerable to recapture method.

The 95% confidence interval of the Petersen estimate of small salmon returns was calculated according to Ricker (1975).

b. Large Salmon Returns

Large salmon returns to the river (N_{lg}) were determined from returns of small salmon based on relative numbers of small and large salmon captured in the recapture trap.

$$\mathbf{N_{lg} = N_{sm} \times Ratio\ Large : Small}$$

In the 1990 and 1991 assessments, the ratio of large to small salmon in the population was considered to be equivalent to that observed in the recreational fishery prior to 1984 when both small and large salmon could be retained (Chaput and Mullins, MS 1991, 1992). However, a commercial salmon fishery was also permitted in those years. The closure of the commercial salmon fishery in 1992 created the potential for increased numbers of large relative to small salmon. Hence, in other mark-recapture studies since 1992, the relative numbers in the population were taken as those observed in the tagging traps operated in the estuary rather than the recreational fishery.

The 95% confidence interval of the estimated ratio of large to small salmon returns was derived by a simulation technique as described above for voluntary tag reporting rate by anglers.

c. Spawning Escapements

Spawning escapements of small and large salmon were obtained by subtracting angling removals from the returns to the river. Angling removals included retained small salmon and an assumed mortality rate of 0.10 on released small and large salmon.

POTENTIAL EGG DEPOSITIONS

Potential egg depositions by small and large salmon spawners were calculated based on estimates of fecundity. Fecundity was estimated based on the mean weight of female small and large salmon and a relative fecundity value of 1,540 eggs/kg taken from (Porter and Chadwick, MS 1983). Small and large salmon can have different relative fecundity (Randall, 1989). However, the current estimate of the proportion of large salmon spawning in the Humber River stock is low on average (<10%) and age-specific fecundity estimates are lacking. The total eggs per small and large salmon spawner was determined by multiplying by the percentage female of small and large salmon. The mean weight and percentage female for small salmon were obtained from retained catches in the recreational fishery at Big Falls. The mean weight of female large salmon is from Porter and Chadwick (MS 1983) and the percentage female was based on commercial catches in the Bay of Islands in 1991 (Chaput and Mullins, MS 1992). These values and calculations are summarized in below.

Year	Small salmon					Large salmon				
	% Female	Mean Wt. Female (kg)	Eggs /kg	Eggs/ Female	Eggs /Fish	% Female	Mean Wt. Female (kg)	Eggs /kg	Eggs/ Female	Eggs /Fish
1990	53.0	1.70	1540	2618	1388	90.0	3.7	1540	5698	5128
1991	69.2	1.33	1540	2048	1417	68.6	3.7	1540	5698	3909
1992	54.2	1.96	1540	3018	1636	69.2	3.7	1540	5698	3943
1993	66.3	1.69	1540	2603	1726	68.6	3.7	1540	5698	3909
1994	50.9	1.70	1540	2618	1332	68.6	3.7	1540	5698	3909
1995	51.4	1.58	1540	2433	1250	68.6	3.7	1540	5698	3909
1996	59.9	1.80	1540	2772	1660	68.6	3.7	1540	5698	3909
1997	59.6	2.00	1540	3080	1836	68.6	3.7	1540	5698	3909
1998	50.0	1.80	1540	2772	1386	68.6	3.7	1540	5698	3909
1999	56.9	1.80	1540	2772	1577	68.6	3.7	1540	5698	3909

Uncertainty in the estimation of potential egg depositions is created by the estimation of the above parameter values as well as estimates of returns and spawning escapements. Potential egg depositions were recalculated using simulation techniques allowing for variation in a number of the parameters including: 1) the ratio of large to small salmon in the population; 2) voluntary tag reporting rate by anglers; 3) tag loss; 4) the fecundity of small and large female salmon; and 5) the percentage of female small and large salmon. Potential egg depositions were recalculated 5000 times allowing a 20% coefficient of variation within a uniform distribution. The frequency distribution and probability distribution of the resulting probable levels of the egg depositions in 1999 were plotted.

CONSERVATION REQUIREMENTS

The conservation egg deposition requirement, was calculated based on 2.4 eggs/m^2 (Elson, 1975), for fluvial habitat (Elson, 1957) and 368 eggs/ha (O'Connell et al., MS 1991) for lacustrine habitat. The egg deposition rate for fluvial habitat includes an adjustment for egg losses due to poaching and disease, whereas, the egg deposition rate for lacustrine habitat does not include an adjustment. The available fluvial habitat estimated for Humber River is 11, 530,700 m^2 (Porter and Chadwick, MS 1983) and the lacustrine habitat is 1,751 ha, excluding Deer Lake (Mullins and Chaput, MS 1995).

The conservation egg deposition requirement for the Humber River is 28.3 million eggs. The conservation requirement expressed in terms of number of spawners is 15,749 small and 934 large salmon based on the mean proportions of small and large salmon in 1992-96 (Mullins et al., MS 1997).

LONG TERM POPULATION TRENDS

Analysis to Detect Recruitment Over-fishing

Details of the analysis to detect recruitment over-fishing are described in O'Connell et al. (1995). Spawning escapements that produced small and large salmon spawning on the Humber River in 1980-1999 were constructed by weighting previous spawning escapements by the smolt age distribution of 1SW salmon on the Humber River in 1993.

RESULTS & DISCUSSION

RECREATIONAL SALMON FISHERY

The recreational salmon fishery on the Humber River opened 1 June and closed 7 September 1999. The river was designated as Class I under the three-year salmon management plan that was introduced in Newfoundland and Labrador in 1999. This designation resulted in an increase in the seasonal retention limit of small salmon from four in 1998 to six in 1999. The restrictions on split seasons that were in effect since 1994 were also removed (Table 1). Based on licence stub returns, the catch was 2,223 small salmon retained, 899 small released and 689 large salmon released in 1999 (Appendix 1). The small salmon retained catch was 26% higher than in 1998 and the small salmon released catch was 60% lower than in 1998. The large salmon released catch was 12% higher than in 1998. The percentage of large salmon in the total catch was 18% in 1999 compared to 13% in 1998 and 9% in 1997.

The increase in the small salmon retained catch and the decrease in the small salmon released catch compared to 1998 was likely due to the increase in retention limit as well as the removal of split season restrictions in 1999. The much higher proportion of small salmon released in 1998 may have been a direct result of the retention limit of one small salmon before 5 July which effectively restricted anglers to catch and release angling only in order to continue fishing. However, lower catches in 1998 could also be explained by the lower population size. Without detailed information on angling effort it is impossible to separate the effects of changes in management measures from those of changes in the population size. Effort data was not available from licence stub information.

OTHER POTENTIAL SOURCES OF MORTALITY

a. Environmental Conditions

Water levels in June and July, normally the period of peak angling on the Humber River, were the lowest in 1992-98 and among the lowest in the 30 year time series (Fig. 3). However, there were no reports of salmon mortality due to low water levels or high temperatures. Lower than normal water levels early in the season would mean better fishing conditions while temperatures remained cool but anglers contend that salmon do not take the fly as well when the water temperatures warm up later in the season.

b. Illegal Removals

All salmon captured in the tagging and recapture traps in 1999 were examined for the presence of net marks, predation and disease. Net marks were noted on 2.4% of all fish examined; 2.2% had scars and 0.3% had some form of fungus (Table 3). Incidence of net marks was similar to 1998, lower than in 1997 (Fig. 4).

c. Predation

There were several unconfirmed reports of seals sighted in June more than 50 km upstream from the mouth of the river and upstream of the recapture trap. Fisheries officers retrieved one dead harbour seal from the Lower Humber River on 9 September 1999.

There were a number of unconfirmed reports of rainbow trout angled near Deer Lake and on the Lower Humber in 1999. There have been other, confirmed, reports in previous years but the data is presently too sparse to judge whether or not incidence of these fish is increasing.

MARKING

a. Distribution of Catches in Tagging Traps

The two tagging traps were operated from early June to mid-August 1999. This was somewhat earlier than in previous years (Table 4). However, based on past experience few salmon enter the river in late August.

The run timing of small salmon at the Lower tagging trap in 1999 was the earliest recorded and the run timing of large salmon was among the earliest (Fig. 5). However, the distribution of daily catches in the two tagging traps indicates that tagging occurred over the entire run in 1999 (Fig. 6). The fact that there were no catches in either the

first or the last few days of operation indicates that immigration was negligible during these periods.

Tag applications from the two tagging traps were combined because the weekly distributions were similar, especially for small salmon (Fig. 7a). However, the distribution of catches did not coincide exactly in the early weeks, especially for large salmon (Fig. 7b). The lower trap intercepts salmon farther from the mouth of the river but few tags were ever recaptured in the upper trap in previous studies. This may reflect the low numbers of tags applied; insufficient time elapsed for random mixing; or that the migration route by-passed the upper trap. In any case, given that the two tagging traps were within 2.0 km of each other in the estuary and that the same tagging methods are employed at each trap, the actual entry of the salmon into the river and availability to recapture would be expected to be similar.

b. Tags Applied

A total of 491 small and 53 large bright salmon were caught in the two tagging traps in 1999 (Table 5). The catch of small salmon was higher than in 1997 and 1998 when total returns to the river were among the lowest since 1992. The catch of large salmon was the lowest since 1992. The proportion of large salmon was less than 50% of the value in 1998 but among the highest since 1992 and about equal to the 1992-98 mean.

A total of 481 small and 51 large salmon were tagged and released in 1999 (Table 6). Two of the large salmon released from the tagging traps were previously tagged with a single tag. No additional tags were applied to these fish.

c. Tag Retention

Of the tagged and released salmon, 391 small and 43 large salmon were double-tagged. The tag retention rate for double-tagged salmon recaptured in the recapture trap and by angling (retained) was 1.0 (Table 7). This indicates that all salmon tagged in 1999 were available for recapture. This result supports the brief tag retention experiment conducted in 1995 when five small salmon tagged in late July on the Humber River were held in captivity for 119 days with zero tag loss at the time of release.

Double-tagged salmon recaptured in the recapture trap had spent up to 38 days at large and salmon recaptured by angling spent up to 78 days at large with no tag loss (Tables 8a-b). Given this result, it seems reasonable to conclude that the tag retention rate estimated based on the method adopted from the Margaree River in 1990-98 would have been under-estimated. Applying the Margaree River method in 1999, would have resulted in a tag retention rate of 0.8020 (95% CI=0.6528-0.9329). Adjusting the number of tags applied, by this value, would have resulted in 20% fewer tags being available for recapture in 1999 and a lower estimate of recapture rate.

The median number of days at large for small salmon recaptured by angling (retained) in 1999 was 22 compared to an average of 13 in 1990-98 (Table 8a). The low water levels in the river in 1999 may have caused lower angling exploitation during part of the season and contributed to longer periods of time at large before recapture.

d. Tags Available

Five small and four large salmon were recaptured at a counting fence operated on Hughes Brook. Hughes Brook flows into the Humber Arm of the Bay of Islands about 1.0 km north of the Lower tagging trap (Fig. 1). Tagged small salmon were also recaptured at Hughes Brook in the past (2-12 in 1990-93, three in 1997 and seven in 1998). This amount of emigration is negligible and would have little effect on the total estimate of returns. As in previous years, when the Hughes Brook counting fence was not operated, the number of tags available for recapture on the Humber River was not adjusted for these recaptures. Hence, returns to Humber River were obtained by subtracting returns to Hughes Brook from the total.

One of the large salmon released from the Upper tagging trap in 1999 was previously tagged as a kelt on Highlands River. There is no way of knowing the river of origin of this fish or its final destination. The fish was again recaptured at the counting fence on Hughes Brook. Whatever its river of origin, this confirms that stray fish do contribute to the spawning escapements on other rivers.

Tags available for recapture in the recapture trap were not adjusted for either tag loss or for tags removed by angling downstream. It is assumed that both tagged and untagged salmon would have been angled at the same rate.

For the purpose of comparison of angling exploitation rates and returns estimates with those in previous years, the number of tags available for recapture by angling were adjusted for the tag retention rate estimated based on the Margaree River method. No additional adjustment was made for tags removed by anglers from released small salmon. Tagged small salmon that were angled and released would have also been available to retention angling for a period of time before being caught and released. For example, in the 1995 assessment (Mullins and Reddin, MS 1996), if the number of tags available to the retention fishery had been adjusted for tags removed from released fish, the exploitation rate calculation would have increased by less than 1.5%.

Tags were not applied at water temperatures above 20 C and few, if any, were applied above 15 C (Fig. 8). Because of the relatively cool temperatures at the time of tagging, the experience of tagging personnel, the fact that fish were submerged in water while being tagged and that injured fish were not tagged, tagging mortality was believed to be negligible. The tag application process takes approximately 45 seconds.

RECAPTURES

a. Recapture Trap

The recapture trap was operated from 12 June to 13 August. Few fish were taken in the last two weeks of operation indicating that recaptures occurred over the entire run (Fig. 9). Water temperatures at this trap were greater than 20 C for much of June and July (Fig. 10). Therefore, handling was kept to a minimum to prevent any handling-induced stress that might lead to fall back of released fish.

All tagged salmon recaptured in the recapture trap were recognized and with the exception of seven small salmon and two large salmon, the tag numbers of all recaptures were recorded. After adjustment of these unrecorded tag numbers for the year of tagging, a total of 39 small and zero large salmon tagged in the estuary in 1999 were recaptured in the recapture trap (Table 9).

A total of three tagged small salmon were sighted a second time. No adjustment was made to account for re-sighting as it was assumed that the same re-sighting rate would apply to both the tagged and untagged catch. Handling-induced stress on tagged fish was minimal. The only difference in the handling of tagged and untagged fish was that tagged fish were momentarily held under water in a dip-net while the tag number was recorded. Handling-induced stress has been shown to caused delayed upstream migration in adult chinook salmon (Bernard et al., 1999). However, actual handling of tagged salmon in the recapture trap was very minimal and did not appear to cause additional stress relative to the untagged salmon.

The weekly distribution of tagged and untagged small salmon at the recapture trap was similar (Fig. 11). There were slight differences of timing in some weeks (Fig. 11-12). However, the distributions were significantly correlated ($r=0.80$, $p<0.01$) indicating random mixing of tagged salmon available for recapture.

b. Angling

Anglers voluntarily returned a total of 44 tags from retained small salmon and two from released large salmon in 1999 (Table 9a). After adjustment for a mean reporting rate of 0.6264 (95% CI=0.5275-0.7253), a total of 70 (95% CI=61-83) tags were recaptured from retained small salmon and three from released large salmon (Table 9c).

There were no recaptures from released small salmon. This may be because under the new fishery management plan, there were no restrictions on when small salmon could be retained during the season resulting in fewer fish released than in previous years.

The weekly distribution of small salmon recaptured by angling was very similar to the distribution in the recapture trap (Fig. 13). The distributions were significantly correlated ($r=0.78$, $p<0.01$) indicating random mixing of tagged and untagged fish available to angling.

Angling recaptures of small salmon occurred on all major segments of the river with the largest number recaptured at Big Falls (Table 10). Big Falls also produced the highest proportion of tag recaptures and the total angling catch in previous years.

Tags applied early in the run were recaptured earlier than those tagged later but overall, recaptures occurred in every week of angling (Table 11). These results indicate that tagged salmon were distributed both spatially and temporally throughout the river system during the period of recapture.

c. Recapture Rate

The rates of recapture in the recapture trap and by angling (unadjusted for reporting rate) were similar (Table 12).

After adjustment of angling recaptures for reporting rate (adj. 1), the rate of recapture by angling in 1999 was 0.15 (95% CI=0.13-0.17) (Table 13). This was 17% lower than the estimate based on adjustment for both reporting rate and tag loss (adj. 2) of 0.18 (95% CI=0.15-0.23). Both of these estimates were higher than estimated for 1998 when angling exploitation was estimated after adjustment of recaptures for both reporting rate and tag loss.

The 1992-98 mean angling exploitation rate unadjusted for tag-loss (adj. 1) was approximately 10% lower than with the adjustment (adj. 2) used in previous years (Table 13).

The angling exploitation rate in 1999 was expected to increase compared to 1998 due to less restriction on the retention of small salmon. It is likely that the retention limit of one small salmon before 5 July 1998 would have resulted in fewer fish being caught, hence, a lower angling exploitation rate in 1998 given that catches of small salmon at Big Falls peaked before that date. The low angling exploitation rate in 1996-99 compared to previous years, in particular, may also have been partially due to the early run timing of small salmon to the river (Fig. 5) resulting in quick passage through the system and shorter availability to the fishery. The highest angling exploitation rate recorded in the period of assessment was in 1994. The total angling effort was lower in 1994 than in 1996 and 1997 but the run timing was later and occurred over a much longer period of time. This may have resulted in the run being available to the fishery longer in 1994 than in 1996 and 1997 and, therefore, the exploitation rate was higher. The closure of the Tailrace portion of Deer Lake (Fig. 1) to angling in 1996 would also have reduced angling exploitation as well as low water levels in June and July (Fig. 3).

TOTAL RETURNS, SPAWNING ESCAPEMENT AND PERCENTAGE OF THE CONSERVATION EGG DEPOSITION ACHIEVED

a. Predictions of Returns Based on Cumulative Weekly Catches

Regressions of returns to the Humber River since 1992 on cumulative catches in the Lower tagging trap to week ending dates in 1998 were significant for four out of six dates tested (Mullins and Caines, MS 1999). The model that explained most of the annual variation was for cumulative catches to 28 June. In five of the six years tested, at least 50% of the run had entered the river by that date. The only exception was in 1993 when 50% of the catch was not reached until 5 July. The 1994 data point was the lowest in all cases suggesting that either the trap was more efficient than in other years or that the population estimate was not comparable with the other years. With the 1994 data point removed, the model explained approximately 90% (R^2=0.9032 p=0.0003) of the annual variation in 1990-98. This model predicted total returns in 1999 of just over 11,000 small salmon (Fig. 14).

However, the proportion of the total catch of small salmon taken in this trap in 1999 was much lower than the 1992-98 mean of 0.58 (Table 5). If the proportion of small salmon caught in the lower trap in 1999 had been equal to the 1992-98 mean, then the prediction would have been about 100% higher

Combining catches to 28 June for years in which both tagging traps were operated resulted in fewer data points available but the model was significant (R^2 = 0.847, p=0.006) and predicted that returns of small salmon in 1999 of over 21,000, about twice as high as in 1998 (Fig. 15).

b. Mark-Recapture Estimates

A total of 2,252 small and 362 large salmon were captured in the recapture trap in 1999 (Table 14a). The proportion of large salmon was higher than observed in the estuary where all salmon were measured. This could be explained by the entry of some large salmon into the river prior to installation of the tagging traps and may be more representative of the ratio of large to small salmon in the population.

Returns of small salmon estimated based on the catches in the recapture trap were higher than estimates based on angling catches (Tables 14b). The estimate based on the recapture trap was only 14% higher than the estimate based on angling (unadj.) and both estimates were within the 95% confidence interval of the other (Fig. 16). However, the recapture trap estimate was 81% higher than the estimate based on angling (adj.1) and more than twice as high as the estimate based on angling (adj. 2) with no overlap of confidence intervals (Table 14, Fig. 16). The angling (adj. 1) estimate was only 26% higher than the estimate based on angling (adj. 2) indicating

that the adjustment for reporting rate has a larger impact on the estimate of returns based on angling than did tag loss.

Each of the three estimates of returns of small salmon based on the angling retained catch was higher than corresponding estimates for 1998 (Table 15). However, estimates of large salmon returns were lower than for 1998 due to the lower ratio of large to small salmon observed in the tagging traps

In order for the angling (adj. 1) estimate of returns to fall within the 95% confidence interval of the estimate based on the recapture trap, angling catches would have needed to be approximately 50% (~1,000 small salmon) higher. A measure of the uncertainty around estimates of angling catch based on licence stub returns is not currently available.

c. Spawning Escapements and Potential Egg Depositions

After adjustment of the returns estimates of small and large salmon based on the recapture trap, for angling removals, spawning escapements would have exceeded the conservation egg deposition requirement in 1999 (Table 16).

Conservation requirements expressed in terms of spawners, for management purposes only, were also exceeded in 1999 (Fig. 17). Spawner requirements are based on the relative proportions of small and large salmon observed in the population in 1992-96. However, these proportions may not represent the true proportions in a stable population.

The percentage of the conservation requirement that would have been achieved in 1990-99 based on the three angling adjustment methods is given in Tables 17. The percentage of the conservation egg deposition requirement achieved based on the recapture trap (Table 16) is higher than would have been achieved based on either of the angling adjustment methods (Table 17).

If only the adjustment for reporting rate (adj. 1) had been used in previous assessments, conservation requirements would have been achieved in five of the last ten years since 1990 instead of four (Table 17). If no adjustments had been applied either for reporting rate or tag loss, conservation requirements would have been achieved in eight of the last ten years. However, considering the uncertainty and annual variability associated with the estimates of angling catch, reporting rate and retention rate used in previous years, no attempt was made at this time to recalculate previous returns estimates based on adjusted parameter values. Suffice to say that these previous estimates should be viewed as minimum values.

d. Sources of Uncertainty

The current assessment of the status of the Humber River Atlantic salmon stock based on the recapture trap is for returns to the river in June to August. While these returns represent by far the majority, there is evidence that a run of large salmon enters the river in the fall, presumably spawning in the lower part of the river. Mullins et al. (MS 1997) determined that the fall run consists of 2SW and 3SW salmon, as well as previous spawners and that the size of the run increased in 1994-96 compared to previous years. However, the population appeared to be low, probably less that 600 salmon, with the 3SW component probably less than 200 salmon. The 3SW component is unique to some southwest Newfoundland rivers and Humber River should be given special protection to minimize and to prevent any increase in fishing mortality.

The probability distributions of potential egg depositions indicated that even with the incorporation of uncertainty associated with the estimation of returns and biological parameters, there was a very high probability that the conservation requirement of 28.6 million eggs was exceeded in 1999 based on the recapture trap method (Fig. 18). The probabilities associated with the three angling adjustment methods were lower and showed a wide range. This was due to the wide range in the estimates of returns. Given that there was no estimate of tag reporting rate available for 1999 and that angling catch statistics were preliminary, these latter three distributions may be biased. The fact that there was no adjustment required to account for reporting rate of tags recovered at the recapture trap and that the catch at the trap was known means that there is less uncertainty associated with the estimates of returns and egg deposition based on this method. Hence, this method is preferred over the angling adjustment methods.

In order to continue to improve the stock assessment technique on the Humber River, it is recommended that tag recovery techniques continue to be developed that are independent of the recreational fishery. This would eliminate the uncertainty associated with estimation of the angling catch and voluntary tag reporting by anglers. It is also recommended that tag loss be estimated annually.

LONG TERM POPULATION TRENDS

Since the closure of the commercial salmon fishery in 1992, with the exception of 1994 and 1997, the number of spawners on the Humber River has generally been above estimates of their cohorts derived by weighting previous spawners by the smolt-age distribution of their progeny (Fig. 19).

Spawners were also above the replacement (diagonal) line (Fig. 20) in four out of seven years since 1992. In 1991, the number of spawners was well below the replacement line. Of the total of ten data points, only two were below the replacement

line (revision of 1998 placed it above the line) indicating that the stock has been in an increasing trend in the last ten years. A healthy stock would have points distributed both above and below the replacement line. Hence, annual fluctuations are to be expected.

In a stock with a healthy spawning population it is suggested that points in the spawner-recruit relationship should fall both above and below the line in a 50:50 distribution. The Humber River stock has been above the replacement line in seven of the last eight years since 1992. This suggests a stock in a growth mode. Also, in a healthy population, the conservation requirement should be achieved each year. In the case of the Humber, this has also occurred in six of the last eight years since 1992. It is concluded from this that the Humber River salmon stock, while below the conservation requirement in some years, is showing signs of improvement. However, growth of the spawning population in some years (ex. 1997 and 1998) was minimal compared to recent years. If the survival rate of year-classes contributing to returns to the river in 2000 is as low as for 1997 and 1998 returns, then low population growth could be experienced in 2000. Because of the potential for over-exploiting the stock if returns are low, exploitation should be closely monitored.

ACKNOWLEDGEMENTS

Special thanks to E. Gaudette, L. Fudge and G. Edmunds for their assistance in the operation of the tagging and recapture traps and in compiling the data. The project was sponsored in part by the Salmon Preservation Association for the Waters of Newfoundland with funding from the Department of Human Resources Development Canada. We are grateful for their continued support.

REFERENCES

Bernard, D.R., J.J. Hasbrouck and S.J. Fleischman. 1999. Handling-induced delay and downstream movement of adult chinook salmon in rivers. Fish. Res. 44, 37-46.

Chaput, G. and C. Mullins. MS 1991. The status of the Atlantic salmon stock of Humber River/Bay of Islands Newfoundland, 1990. CAFSAC Res. Doc. 91/14, 28 p.

Chaput, G. and C. Mullins. MS 1992. The status of the Atlantic salmon stock of Humber River/Bay of Islands Newfoundland, 1991. CAFSAC Res. Doc. 92/28, 34 p.

Chaput G., R. Jones and C. C. Mullins. MS 1992. A practical assessment of bus route creel surveys and lattice sampling design for estimating the recreational catch of Atlantic salmon. CAFSAC Working Paper 92/16.

Chaput, G., R. Jones, L. Forsythe and P. Leblanc. MS 1993. Assessment of Atlantic salmon in the Margaree River, Nova Scotia, 1992. DFO Atl. Fish. Res. Doc. 93/14, 39 p.

Diaconis, P. and B. Efron. 1983. Computer-Intensive Methods in Statistics. Sci. Amer. Vol. 248 No. 5: 116-130 p.

Efron, B. and R. Tibshirani. 1986. Bootstrap Methods for Standard Errors, Confidence Intervals, and Other Measures of Statistical Accuracy. Statistical Science 1:54-75 p.

Elson, P.F. 1957. Using hatchery reared Atlantic salmon to best advantage. Can. Fish. Cult. 21:7-17.

Elson, P.F. 1975. Atlantic salmon rivers smolt production and optimal spawning. An overview of natural production. Int. Atl. Salmon Found. Spec. Publ. Ser. 6:96-119.

Mullins, C. C. and R. R. Claytor. MS 1989. Recreational Atlantic salmon catch, 1987 and 1988, and annual summaries, 1973-1988, for West Newfoundland and South Labrador, Gulf Region. Can. Data Rep. Fish. Aquat. Sci. No. 748, 192 p.

Mullins, C. C. and G. Chaput. MS 1993. The Status of the Atlantic Salmon Stock of Humber River/Bay of Islands, Newfoundland, 1992. DFO Atl. Fish. Res. Doc. 93/34, 53 p.

Mullins, C. C. and G. Chaput. MS 1995. The Status of the Atlantic Salmon Stock of Humber River/Bay of Islands, Newfoundland, 1993. DFO Atl. Fish. Res. Doc. 95/84, 48 p.

Mullins, C. C. and D. G. Reddin. MS 1995. The Status of the Atlantic Salmon Stock of Humber River/Bay of Islands, Newfoundland, 1994. DFO Atl. Fish. Res. Doc. 95/115, 59 p.

Mullins, C. C. and D. G. Reddin. MS 1996. The Status of the Atlantic Salmon Stock of Humber River, Newfoundland, 1995. DFO Atl. Fish. Res. Doc. 96/139, 51 p.

Mullins, C. C., J. A. Wright, and R. R. Claytor. MS 1989. Recreational Atlantic salmon catch, 1986 and annual summaries, 1953-1986 for West Newfoundland and South Labrador, Gulf Region. Can. Data Rep. Fish. Aquat. Sci. No. 715, 124 p.

Mullins, C. C., T.R. Porter and J.B. Dempson. MS 1997. The Status of the Atlantic Salmon Stock of Humber River, Newfoundland, 1996. Can. Stock Assessment Secretariat Res. Doc. 97/37, 53 p.

Mullins, C.C. and D. Caines. MS 1998. Status of the Atlantic salmon (*Salmo salar* L.) stock of Humber River, Newfoundland, 1997. CSAS Res. Doc. 98/106, 44p.

Mullins, C.C. and D. Caines. MS 1999. Status of the Atlantic salmon (*Salmo salar* L.) stock of Humber River, Newfoundland, 1998. CSAS Res. Doc. 99/100, 60p.

O'Connell, M. F., J. B. Dempson, and R. J. Gibson. MS 1991. Atlantic salmon (Salmo salar L.) smolt production parameter values for fluvial and lacustrine habitats in insular Newfoundland. CAFSAC Res. Doc. 91/19, 11 p.

O'Connell, M. F., D. G. Reddin, and E. G. M. Ash. MS 1995. Status of Atlantic Salmon (*Salmo salar* L.) In Gander River, Notre Dame Bay (SFA 4), Newfoundland, 1994. DFO Atl. Fish. Res. Doc. 95/123, 25 p.

O'Connell, M.F., N.M. Cochrane, and C.C. Mullins. MS 1998. An analysis of the license stub return system in the Newfoundland Region, 1994-97. CSAS Res. Doc. 98/111, 67p.

Porter, T. R. and E. M. P. Chadwick. MS 1983. Assessment of Atlantic salmon stocks in statistical areas K and L, western Newfoundland, 1982. CAFSAC Res. Doc. 83/87, 86 p.

Porter, T. R., L. G. Riche, and G. R. Traverse. MS 1974. Catalogue of rivers in Insular Newfoundland Volume C. Data Record Series No. NEW/D-74-9.

Randall, R. G. 1989. Effect of sea-age on the reproductive potential of Atlantic salmon (*Salmo salar*) in eastern Canada. Can. J. Fish. Aquat. Sci. 46: 2210-2218.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Board Can. 191:382 p.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Company, 776 p.

White, G.C. and R.A. Garrot. 1990. Analysis of Wildlife Radio-Tracking Data. Academic press, Inc.

Zale, Alexander V. and Mark B. Bain. 1994. Estimating Tag-Reporting Rates with Postcards as Tag Surrogates. North American Journal of Fisheries Management, Vol. 14, No. 1, pp. 208-211.

Table 1. Recreational and commercial fishery management measures implemented in Newfoundland and Labrador since 1978 that would have influenced the Humber River salmon stock.

Year	Recreational Fishery									Commercial Fishery (SFA 13)	
	Season Dates Open - Closed	Small salmon					Large salmon	Closures	Fall Fishery (H&R) Open – Closed	Season Open – Closed	Season Quotas
		Season Bag Limit	Season Quotas		Daily Bag Limit						
			SFA 13	Adies Lake	Retained	Released*					
1978										1 Jun – 10 Jul	
1984							H&R			5 Jun – 10 Jul	
1987		15					H&R			5 Jun – 10 Jul	
1990		15					H&R			5 Jun – 10 Jul	35t
1991	1 Jun - 2 Sep	10					H&R			5 Jun – 10 Jul	25t reached 6 Jul
1992	6 Jun - 7 Sep	8	5000	100	2	4	H&R	SFA 13 quota reached 1 Aug. H&R 2 Aug - 7 Sep		Moratorium in Nfld.	
1993	6 Jun - 6 Sep	8	5200	100	1	4	H&R	Adies Lake closed 31 Jul quota not reached		Moratorium in Nfld.	
1994	4 Jun - 5 Sep	3 before 31 Jul 3 after 31 Jul		100	2	4	H&R	Adies Lake closed 31 Jul quota not reached		Moratorium in Nfld.	
1995	3 Jun - 4 Sep	3 before 31 Jul 3 after 31 Jul		100	2	4	H&R	Adies Lake closed 30 Jul quota not reached.	.	Moratorium in Nfld.	
1996	3 Jun - 2 Sep	3 before 31 Jul 3 after 31 Jul		100	2	4	H&R	Adies Lake closed 30 Jul quota not reached	3-30 Sep	Moratorium in Nfld.	
1997	6 Jun - 1 Sep	3 before 31 Jul 3 after 31 Jui		100	2	4	H&R	Retention 6 Jun – 27 Jul H&R 28 Jui - 1 Sep Adies Lake closed 30 Jul quota not reached	2-30 Sep	Moratorium in Nfld. and Lab.	
1998	6 Jun - 7 Sep	1 before 5 Jul 3 after 5 Jul.		100	1	2	H&R	None	8-27 Sep	Moratorium in Nfld. and Lab.	
1999	1 Jun – 7 Sep	6		None	2	4	H&R	None	8 Sep – 7 Oct	Moratorium in Nfld. and Lab.	

* Note: Daily bag limit of released fish is for small and large combined.

Table 2. Equations used in estimation of angling exploitation rate, total catch and total returns of Atlantic salmon to the Humber River, 1998. Parameters in bold type changed values with each iteration of the

1. RECAPTURE RATE (***er***)

a. Trap = **Tags Recaptured (R)** / **Tags Available (M)**

b. Angling (unadj.) = **Tags Recaptured (R)** / **Tags Available (M)**

c. Angling (adj.1) = Tags Recaptured (Radj.) / Tags Available (M)

R (adj.) = Tags Returned / Reporting Rate (rr)

rr = **Tags Returned from Big Falls** / **Tags Recaptured at Big Falls** = **57** / **91** = **0.6264** (95% CI=0.5275-0.7253)

d. Angling (adj.2) = Tags Recaptured (Radj.) / Tags Available (Madj.)

M (adj.) = Tags Applied x (1-Tag Loss Rate (TL))

TL = **(Tags shed rate x Median Days to Recapture)**
Tag Shed Rate=0.009 tags/day (95% CI=0.0061-0.0112)
Range of Days to Recapture = 4 to 78 days;
Median = 22 (95% CI=11-31)

2. CATCH-Small salmon (C_{sm})

a. Trap = Total Catch of Small in the Recapture Trap (unadjusted for fall back).

b. Angling = Retained Catch Only
(From Licence Stub Returns (O'Connell et al., MS 1998))

3. RETURNS-Small (N_{sm}) = $\frac{C_{sm}}{er}$ or $\frac{M \times C_{sm}}{R}$
(Petersen single census)

4. RETURNS-Large (N_{Lg}) = N_{Sm} x Ratio Large:Small in Recapture Trap
Ratio Large:Small = 362/2252 = 0.1607 (95% CI=0.1465-0.1758)

Equations in bold type were solved 5000 times to generate the distribution from which 95% confidence limits were determined.

Table 3. Incidence of net marks and other evidence of potential sources of mortality on the Humber River, 1999.

Location		NUMBER			PERCENTAGE		
		SMALL	LARGE	TOTAL	SMALL	LARGE	TOTAL
Tagging Traps	net marks	23	1	24	4.7	1.9	4.4
	scars	30	6	36	6.1	11.3	6.6
	fungus	0	0	0	0.0	0.0	0.0
	tot injuries	53	7	60	10.8	13.2	11.0
	unmarked	441	46	487	89.8	86.8	89.5
	total	491	53	544	100.0	100.0	100.0
Recapture Trap	net marks	44	7	51	2.0	1.9	2.0
	scars	26	7	33	1.2	1.9	1.3
	fungus	8	1	9	0.4	0.3	0.3
	tot injuries	78	15	93	3.5	4.2	3.6
	unmarked	2173	346	2519	96.5	95.8	96.4
	total	2252	361	2613	100.0	100.0	100.0
TOTAL	net marks	67	8	75	2.4	1.9	2.4
	scars	56	13	69	2.0	3.1	2.2
	fungus	8	1	9	0.3	0.2	0.3
	tot injuries	131	22	153	4.8	5.3	4.8
	unmarked	2614	392	3006	95.3	94.7	95.2
	total	2743	414	3157	100.0	100.0	100.0

Note: some fish may have had more than one type of mark.

Table 4. The periods of operation of two tagging traps, recapture trap and angling recaptures on the Humber River, 1990-1999.

Year	Period of Marking				Period of Recaptures			
	Lower Trap		Upper Trap		Recapture Trap		Angling	
	Start	Finish	Start	Finish	Start	Finish	Start	Finish
1990	9-Jun	20-Sep	.	.	.	.	1-Jun	2-Sep
1991	7-Jun	29-Aug	.	.	.	.	1-Jun	8-Sep
1992	7-Jun	30-Sep	.	.	.	.	1-Jun	1-Aug
1993	10-Jun	1-Sep	2-Jun	31-Aug	.	.	6-Jun	6-Sep
1994	6-Jun	1-Sep	1-Jun	29-Aug	.	.	4-Jun	5-Sep
1995	1-Jun	31-Oct	7-Jun	18-Sep	.	.	3-Jun	4-Sep
1996	1-Jun	3-Oct	24-May	2-Oct	.	.	3-Jun	2-Sep
1997	10-Jun	1-Sep	3-Jun	3-Sep	.	.	1-Jun	1-Sep
1998	2-Jun	25-Aug	29-May	29-Aug	2-Jul	13-Aug	6-Jun	6-Sep
1999	3-Jun	14-Aug	27-May	17-Aug	12-Jun	13-Aug	1-Jun	7-Sep

Table 5. Catches and annual variation in the proportion of small and large Atlantic salmon in tagging traps operated on the Humber River, 1989-99.

Year	Lower Tagging Trap			Upper Tagging Trap			Total			Prop.	Prop.	Prop.	Ratio
	Small	Large	Total	Small	Large	Total	Small	Large	Total	Lower	Small	Large	Large:Small
1989	2	5	7	.	.	.	2	5	7	.	0.2857	0.7143	2.5000
1990	257	22	279	.	.	.	257	22	279	.	0.9211	0.0789	0.0856
1991	104	4	108	.	.	.	104	4	108	.	0.9630	0.0370	0.0385
1992	181	29	210	.	.	.	181	29	210	.	0.8619	0.1381	0.1602
1993	699	45	744	244	11	255	943	56	999	0.74	0.9439	0.0561	0.0594
1994*	438	79	517	187	3	190	625	82	707	0.73	0.8840	0.1160	0.1312
1995	844	104	948	1115	39	1154	1959	143	2102	0.45	0.9320	0.0680	0.0730
1996	516	63	579	461	23	484	977	86	1063	0.54	0.9191	0.0809	0.0880
1997	248	47	295	136	20	156	384	67	451	0.65	0.8514	0.1486	0.1745
1998	65	19	84	136	56	192	214	80	294	0.29	0.7279	0.2721	0.3738
1999	72	19	91	419	34	453	491	53	544	0.17	0.9026	0.0974	0.1079
Mean (92-98)**	427	55	482	326	22	347	755	78	832	0.56	0.9068	0.0918	0.1024

* Upper trap fished 10 km upstream.

** Mean for proportion in lower trap is for 1993-98.

Table 6. Condition of small and large salmon captured in tagging trap on Humber River, 1999.

	Large					SKelt			Small				
	Highlands R. Fish	Recap 1995	Released	Tagged	ALL	Recap 1998	Tagged	ALL	Injured	Mortality	Released	Tagged	ALL
AREA													
1	.	1	1	17	19	.	1	1	1	1	.	70	72
2	1	.	1	32	34	1	4	5	.	.	8	411	419
ALL	1	1	2	49	53	1	5	6	1	1	8	481	491

*Recaptured previously tagged as kelts.

Table 7. Results of experiment to estimate the rate of tag retention on Humber River, 1999.

Tag Retention Rate

Recapture	Recaptured Doubles			Recaptured Singles			Total			Tag Retention		
Method	Small	Large	Total	Small	Large	Total	Small	Large	Total	Small	Large	Total
Recapture Trap	20	0	20	0	0	0	20	0	20	1.0	-	1.0
Angling	40	1	41	1	0	1	41	1	42	1.0	-	1.0

Table 8. Annual variation in the number of days at large before recapture by angling and in the recapture trap. Tag retention rate is calculated based on the Margaree River methodology (assuming a tag-loss rate of 0.009 tags per day at large).

a. Angling

Year	No. Tags	No. Days At Large Before Recapture			Tag Retention Rate
		Minimum	Maximum	Median	
1990	27	3	52	13.0	0.883
1991	9	3	42	5.0	0.955
1992	27	4	47	12.0	0.892
1993	119	0	80	15.0	0.8650
1994	92	2	77	16.6	0.8506
1995	189	0	71	13.4	0.8794
1996	79	3	72	12.0	0.8920
1997	33	2	40	16.0	0.8560
1998	13	3	57	11.0	0.9010
1999	41	4	78	22.0	0.8020 (95% CI=0.6528-0.9329)
Total (90-98)	588	0	80	13.0	0.8830 (95% CI=0.8570-0.9220)

b. Recapture Trap

Year	No. Tags	No. Days At Large Before Recapture			Tag Retention Rate
		Minimum	Maximum	Median	
1998	2	.	.	.	.
1999	29	3	38	7	0.9370

Table 9. Recaptures of tagged small and large salmon in the recapture trap and by angling on the Humber River, 1999. Adjustments are made to account for unrecorded tag sightings in the recapture trap and for voluntary tag reporting rate by anglers.

a. Recorded Tag Recaptures

Recapture	Tagged in 1999			Previously Tagged			Total			Proportion Tagged in 1999		
Method	Small	Large	Total	Small	Large	Total	Small	Large	Total	Small	Large	Total
Recapture Trap	32	0	32	1	3	4	33	3	36	0.9697	0.00	0.8889
Angling	44	2	45	1	0	1	45	2	47	0.9778	1.00	0.9574

b. Unrecorded Tag Recaptures

Recapture	Unrecorded Tag Sightings			No. Tagged in 1999		
Method	Small	Large	Total	Small	Large	Total
Recapture Trap	7	2	9	7	0	7

c. Total Recaptures 1999

Recapture			
Method	Small	Large	Total
Recapture Trap*	39	0	39
Angling (adj.1)**	70	3	72

* Adjusted for unrecorded tag sightings.

** Adjusted for reporting rate of 0.6264 (95% CI=0.5275-0.7253).

Table 10. Location of angling recaptures of small and large salmon on the Humber River, 1999.

RECAPTURE YEAR: 1999
AND SIZE: Small

			RECAPTURE LOCATION									
			Humber River	Lower Humber	Deer Lake	Little Falls	Big Falls	Adies Stream	Adies Lake	Harrimans Steady	Taylors Brook	ALL
			N	N	N	N	N	N	N	N	N	N
AREA	R1GEAR	RELWK										
1	Retained	23	.	.	.	.	2	.	.	.	.	2
		24	.	.	.	1	2	.	.	.	1	4
		25	.	.	.	.	.	1	.	.	.	1
		27	.	1	.	.	.	.	.	.	.	1
		ALL	.	1	.	1	4	1	.	.	1	8
2	Retained	RELWK										
		24	.	.	1	1	9	4	1	2	2	20
		25	2	.	2	.	2	2	.	2	5	15
		26	.	.	1	.	.	.	.	.	.	1
		ALL	2	.	4	1	11	6	1	4	7	36
ALL	Retained	RELWK										
		23	.	.	.	.	2	.	.	.	.	2
		24	.	.	1	2	11	4	1	2	3	24
		25	2	.	2	.	2	3	.	2	5	16
		26	.	.	1	.	.	.	.	.	.	1
		27	.	1	.	.	.	.	.	.	.	1
		ALL	2	1	4	2	15	7	1	4	8	44

Table 11. Weekly distribution of releases and angling recaptures of small and large salmon on the Humber River, 1999.

RECAPTURE YEAR 1999
AND FLTCLASS Small

			RECAPTURE WEEK												
			.	24	25	26	27	28	29	30	31	32	33	34	35	ALL
			N	N	N	N	N	N	N	N	N	N	N	N	N	N
AREA	R1GEAR	RELWK														
1	Retained	23	.	.	2	.	.	.	.	.	.	.	.	.	.	2
		24	.	1	1	.	1	.	.	.	.	1	.	.	.	4
		25	.	.	.	.	.	.	.	.	.	.	1	.	.	1
		27	.	.	.	.	.	.	.	.	.	1	.	.	.	1
		ALL	.	1	3	.	1	.	.	.	.	2	1	.	.	8
2	Retained	RELWK														
		24	.	.	6	2	1	4	1	.	1	1	.	.	4	20
		25	3	.	.	5	1	1	.	2	.	1	1	1	.	15
		26	.	.	.	.	.	.	1	.	.	.	.	.	.	1
		ALL	3	.	6	7	2	5	2	2	1	2	1	1	4	36
ALL	Retained	RELWK														
		23	.	.	2	.	.	.	.	.	.	.	.	.	.	2
		24	.	1	7	2	2	4	1	.	1	2	.	.	4	24
		25	3	.	.	5	1	1	.	2	.	1	2	1	.	16
		26	.	.	.	.	.	.	1	.	.	.	.	.	.	1
		27	.	.	.	.	.	.	.	.	.	1	.	.	.	1
		ALL	3	1	9	7	3	5	2	2	1	4	2	1	4	44

Table 12. Comparison of tag recapture rates in the recapture trap and by angling on Humber River, 1999.

Recapture Rate

Recapture Method	Marks Available			Recaptures 1999			Recapture Rate				
	Small	Large	Total	Small	Large	Total	Small	Large	Total	95% CI (Small)*	
Recapture Trap	481	51	532	39	0	39	0.08	0.00	0.07	0.06	0.11
Angling (unadj.)	481	51	532	44	2	45	0.09	0.04	0.08	0.07	0.12
Angling (adj.1)	481	51	532	70	3	73	0.15	0.06	0.14	0.13	0.17
Angling (adj.2)	386	41	427	70	3	73	0.18	0.07	0.17	0.15	0.23

*95% CI determined by simulation techniques.

Table 13. Comparison of angling exploitation rates for retained small salmon calculated for the Humber River, 1990-99. Estimates are derived based on angling using three adjustment methods. Unadj.=no adjustment for tag loss or reporting rate; adj.1=adjustment for reporting rate; adj.2=adjustment for tag loss and reporting rate.

	Marks		Angling Recaptures		Exploitation Rate		
Year	unadj.	adj.*	unadj.	adj.**	unadj.	adj.1	adj.2
1990	202	156	27	39	0.13	0.19	0.25
1991	55	42	9	13	0.16	0.23	0.25
1992	152	117	27	39	0.18	0.25	0.25
1993	818	708	119	159	0.15	0.19	0.23
1994	596	507	92	143	0.15	0.24	0.28
1995	1912	1682	189	310	0.10	0.16	0.18
1996	936	835	79	130	0.08	0.14	0.16
1997	369	316	33	52	0.09	0.14	0.16
1998	196	177	15	24	0.08	0.12	0.14
1999	481	386	44	70	0.09	0.15	0.18
Mean (92-98)	711	620	79	122	0.12	0.18	0.20
Std					0.04	0.05	0.05
95% CI+-					0.04	0.05	0.05
CV					34	29	27
N					7	7	7

* Adjusted for tag loss.

Table 14. Catches of small and large in the recapture trap and by angling and estimated returns to the Humber River, 1999.

a. Catch (unadj.)

Recapture Method	Small			Large	Total	Ratio Large:Sm
	Ret.	Rel.	Total			
Recapture Trap	.	.	2252	362	2614	0.1607
Angling	2223	899	3122	689	6933	0.2207

b. Returns Estimate

Recapture Method	Small			Large*			Total		
	N	95% CI		N	95% CI		N	95% CI	
Recapture Trap	27775	20969	38138	4463	3072	6705	32238	24041	44843
Hughes	190	.	.	30	.	.	220	.	.
Recapture Trap (adj.)	27585	20779	37948	4433	3042	6675	32018	23821	44623
Angling (unadj.)	24301	18674	32661	2622	1522	4458	26924	20196	37119
Angling (adj.1)	15275	12472	19112	1648	1016	2609	16923	13488	21721
Angling (adj.2)	12258	9930	15071	1323	809	2057	13581	10739	17128

*Population estimate of large salmon is based on ratio large to small salmon in the recapture trap of 0.1607 (95% CI=0.1465-0.1758).

Table 15. Comparison of returns estimates of small and large salmon calculated for the Humber River, 1990-99. Estimates are derived based on angling using three adjustment methods.Unadj.=no adjustment for tag loss or reporting rate; adj.1=adjustment for reporting rate; adj.2=adjustment for tag loss and reporting rate. The ratio of large to small is from tagging traps.

	Retained Catch	Population Estimate Small			Ratio Large:	Population Estimate Large		
Year	Small	unadj.	adj.1	adj.2	Small	unadj.	adj.1	adj.2
1990	3054	22848	15948	12216	0.07	1599	1116	855
1991	1431	8745	6104	5724	0.07	612	427	401
1992	4349	24483	17089	**17571**	0.1676	4103	2864	2945
1993	4161	28603	21452	18477	0.0352	1007	755	650
1994	2228	14434	9279	**7995**	0.1288	1859	1195	1030
1995	5150	52099	31713	27898	0.0740	3855	2347	2064
1996	4740	56160	34128	30445	0.0880	4942	3003	2679
1997	2447	27362	17364	14866	0.1745	4775	3030	2595
1998	1765	22922	14414	13016	0.3738	8568	5388	4865
1999	2223	24301	15275	12258	0.1079	2622	1648	1323
Mean (92-98)	3549	32295	20777	18610	0.1488	4159	2655	2404
Std	1362	15640	9094	8015	0.1112	2441	1506	1387
95% CI+-	1260	14465	8411	7413	0.1029	2258	1393	1283
CV	38	48	44	43	75	59	57	58
N	7	7	7	7	7	7	7	7

Note: Population estimate in 1992 based on exploitation rate from Creel survey. Actual estimate in 1994 based on Darroch stratified approach.

Note: Catch in 1994 does not include catch of 295 small in Lower Humber.

Note: Adjusted ER from 1990 used to estimate returns in 1991 and 1992.

Table 16. Atlantic salmon returns, spawning escapements and percentage of the conservation requirement achieved on the Humber River in 1990-99. Returns in 1999 are based on marking and recaptures in the recapture trap and returns in 1990-98 are based on recaptures by angling. Angling catches of small salmon in 1990-97 are based on creel surveys and catches in 1998-99 are based license stub returns.

Conservation egg deposition requirement: 28.3 million eggs

	Estimated Returns			Angling Catch			Spawning Escapement			Egg	% Egg			
				Small		Large				Deposition	Requirement			
Year	Small	Large	Total	Retained	Released	Released	Small	Large	Total	(x 10^6)	Achieved	95% CI		Diff.
1990	12216	855	13071	3054	.	75	9162	848	10010	17	60	.	.	.
1991	5724	401	6125	1431	53	11	4288	400	4687	8	27	.	.	.
1992	17571	2945	20516	4349	317	177	13191	2927	16118	33	117	.	.	.
1993	18477	636	19113	4161	303	125	14286	624	14909	27	96	.	.	.
1994	7995	1030	9025	2523	1438	166	5328	1013	6342	11	40	.	.	.
1995	27898	2064	29963	5150	1881	233	22560	2041	24601	36	128	.	.	.
1996	30445	2679	33125	4740	3016	237	25404	2655	28059	53	186	.	.	.
1997	14866	2595	17461	2447	1433	133	12276	2582	14857	33	115	91	169	78
1998*	13016	4865	17881	1765	2270	618	11024	4803	15827	34	120	82	185	103
1999	27585	4433	32018	2223	899	689	25272	4364	29636	57	201	144	290	146
Mean (92-98)	18610	2402	21012	3591	1523	241	14867	2378	17245	32	115			

* Data for 1998 has been updated based on revised angling statistics.

Table 17. Comparison of percentage of the conservation requirement achieved on the Humber River, 1990-99. Estimates are derived based on angling using three adjustment methods. Unadj.=no adjustment for tag loss or reporting rate; adj.1=adjustment for reporting rate; adj.2=adjustment for tag loss and reporting rate.

Year	Percentage Achieved		
	unadj.	adj.1	adj.2
1990	126	83	60
1991	45	29	27
1992	173	113	117
1993	163	115	96
1994	81	47	39
1995	259	148	128
1996	368	212	186
1997	226	137	115
1998	220	134	120
1999	158	94	73
Mean (92-98)	213	130	114
Std	89	49	43
95% CI+-	197	120	106
CV	42	38	38
N	7	7	7

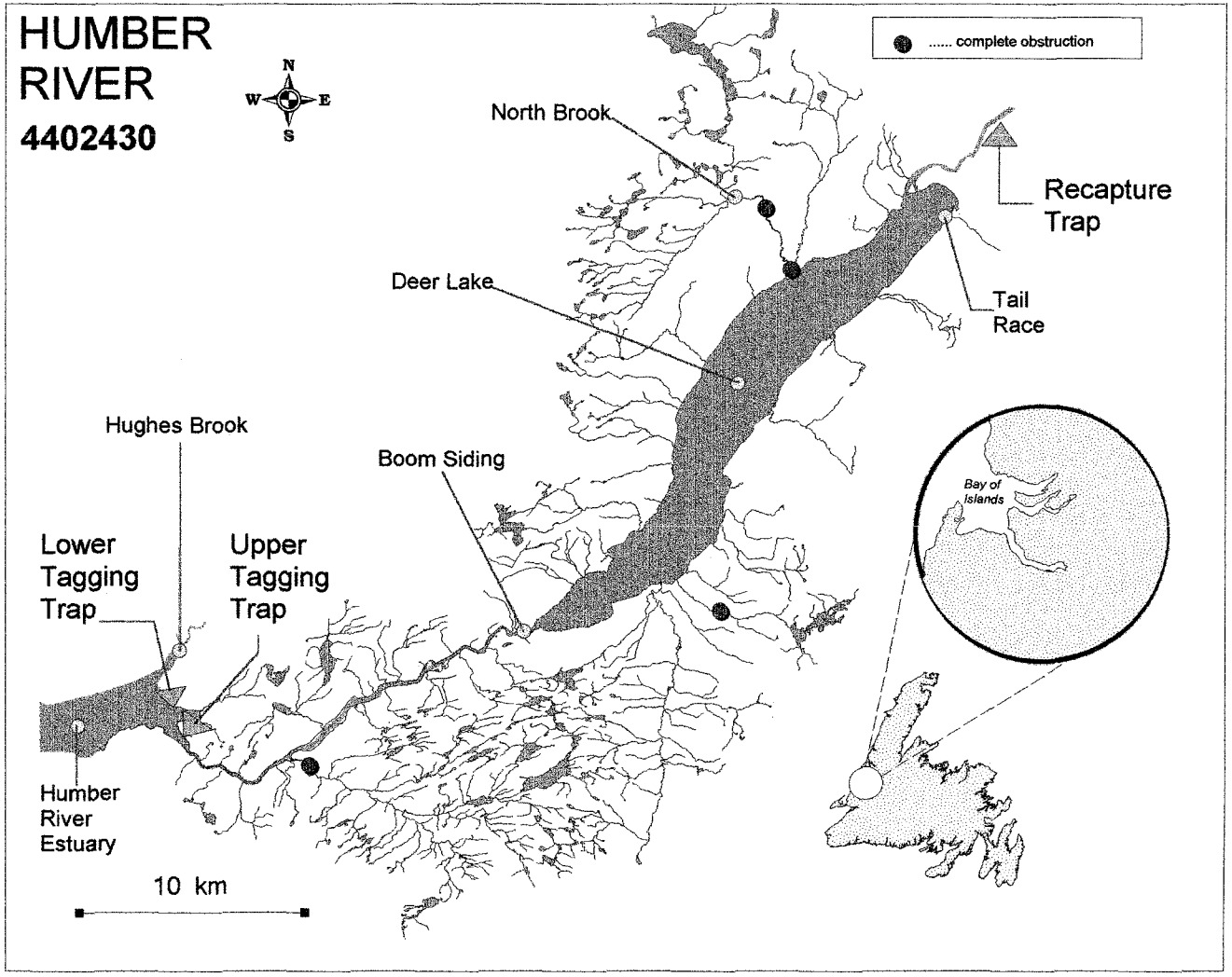


Figure 1. Location of major features of the lower portion of the Humber River, Newfoundland.

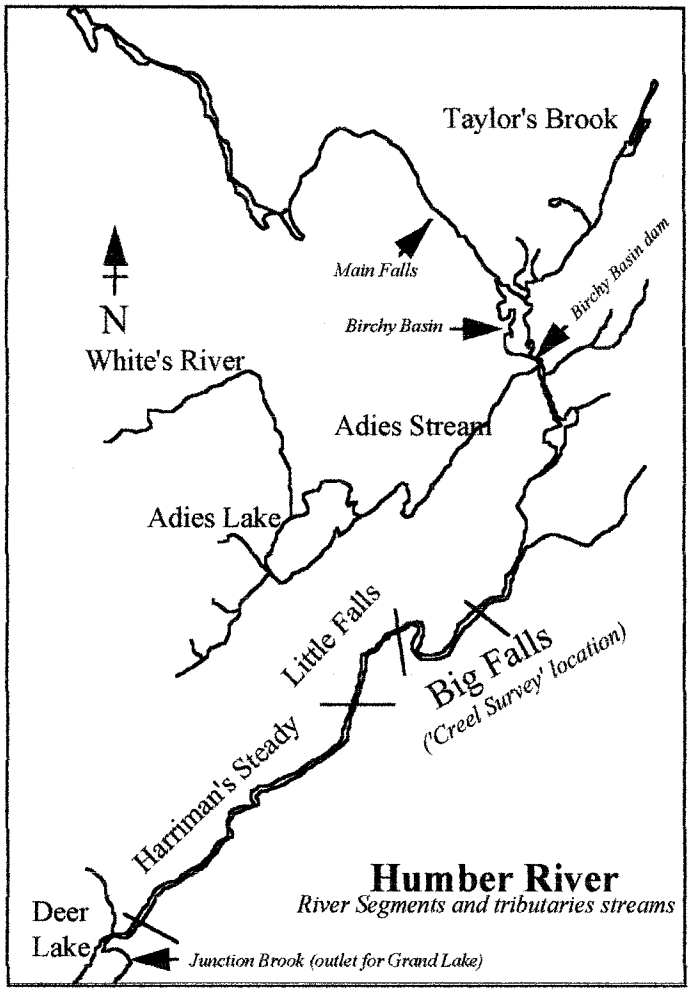


Figure 2. River segments of the Humber River, upstream of Deer Lake and showing the Big Falls Creel Survey location.

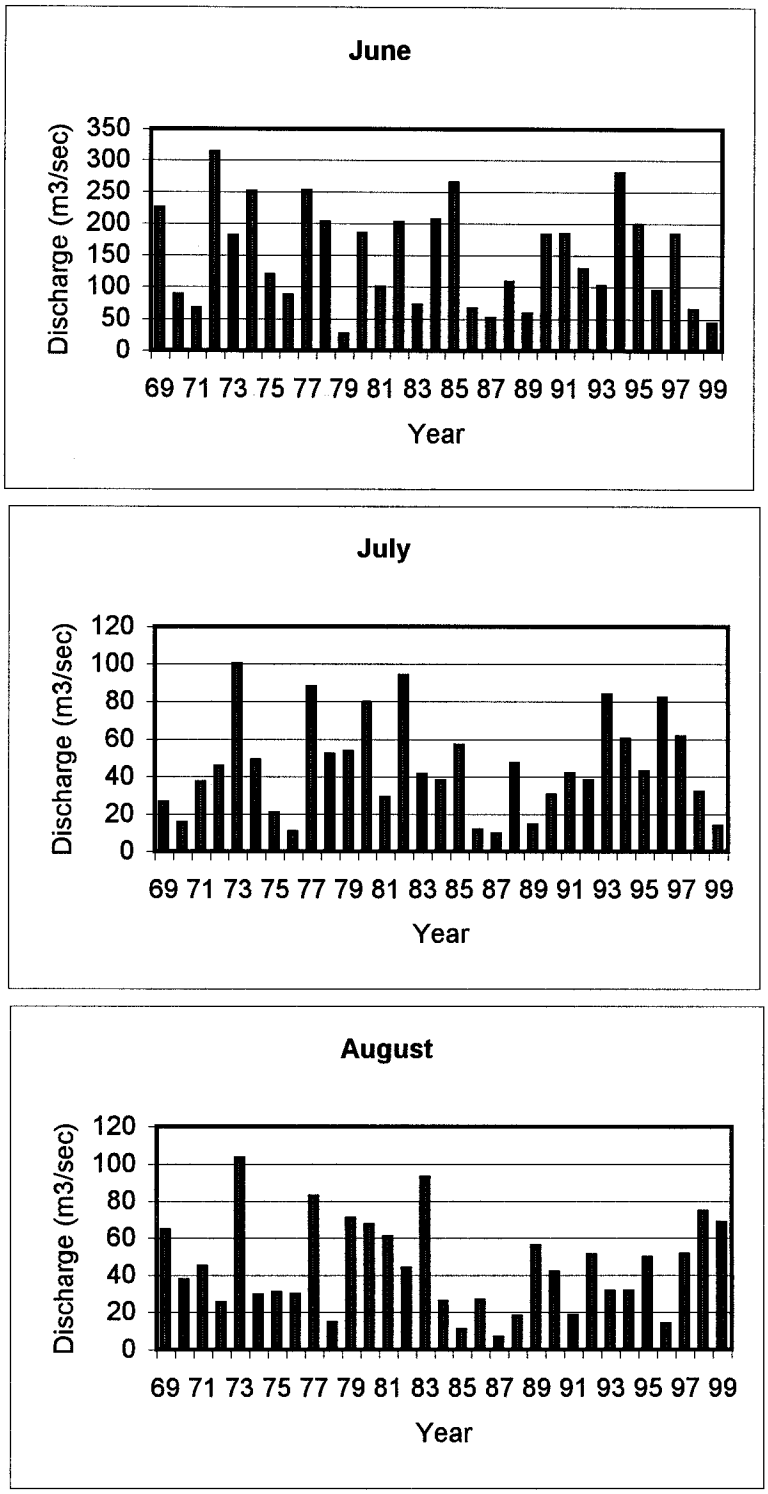


Figure 3. Mean monthly water levels recorded in the upper Humber River, 1969-99. Water discharge data were provided by Environment Canada and the Newfoundland Department of Environment and Labour, Water Resources Management Division. Data were collected from station number 02YL001.

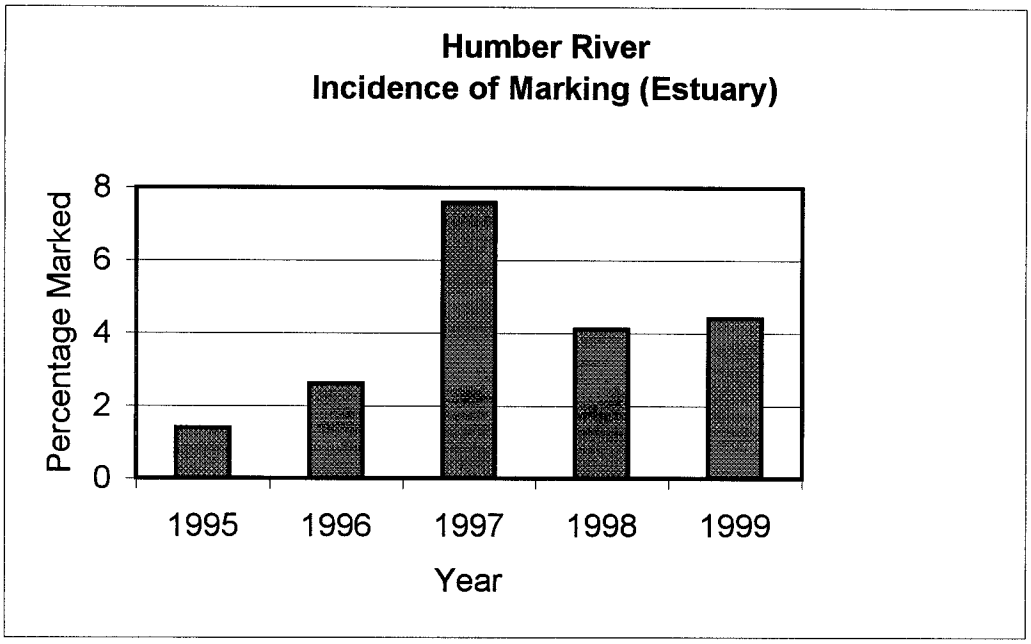
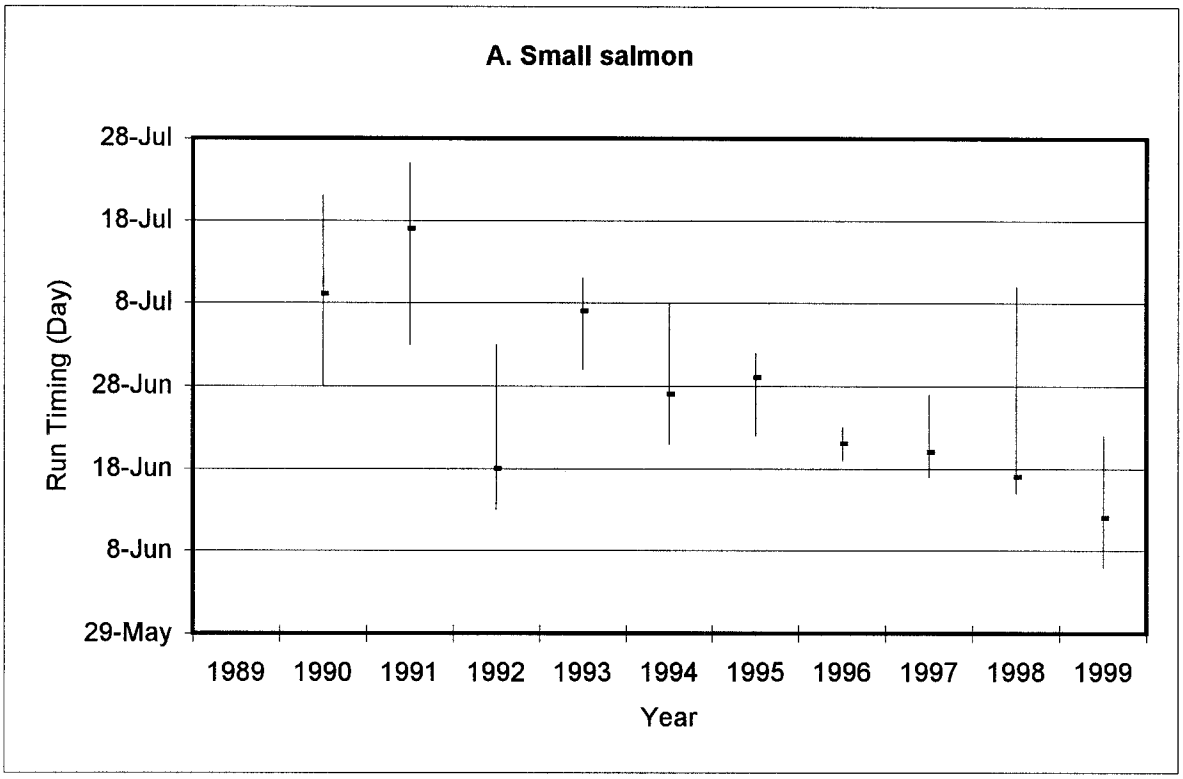


Figure 4. Summary of observations of net marks on Atlantic salmon in the estuary of the Humber River, 1995-99.



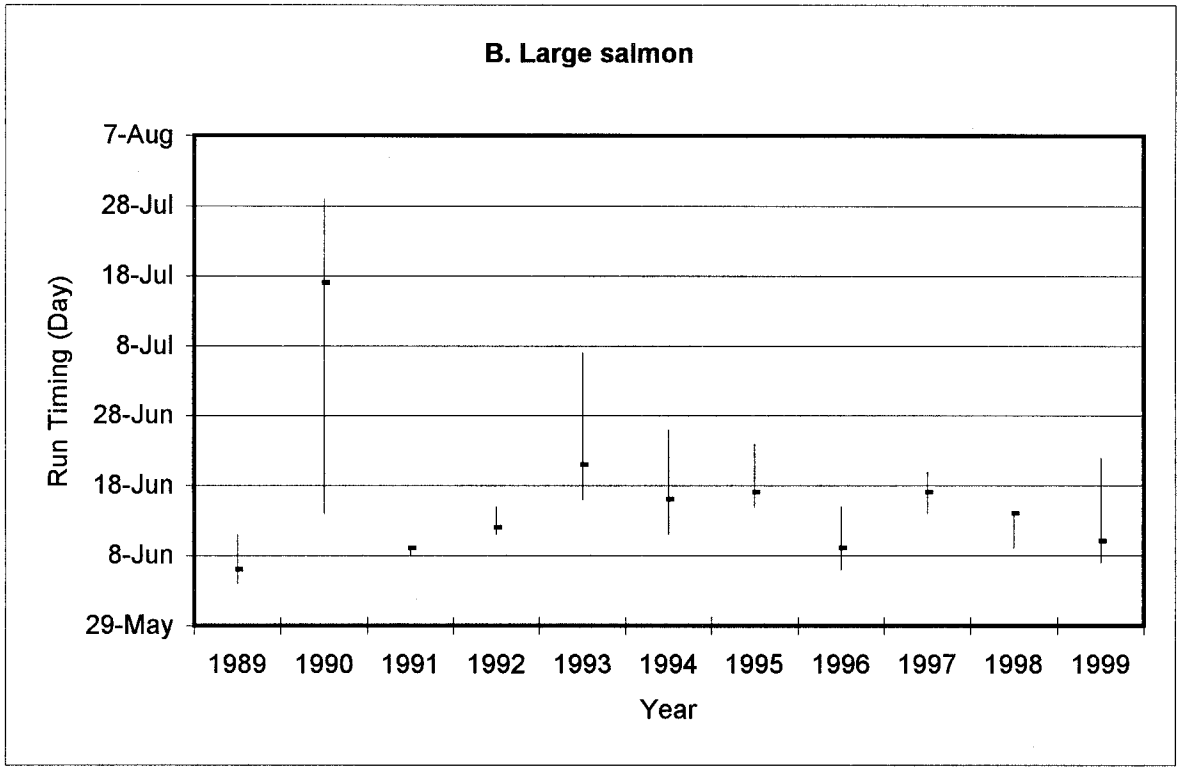


Figure 5. Run timing of small and large salmon in the lower tagging trap operated in the estuary of the Humber River, 1992-99.

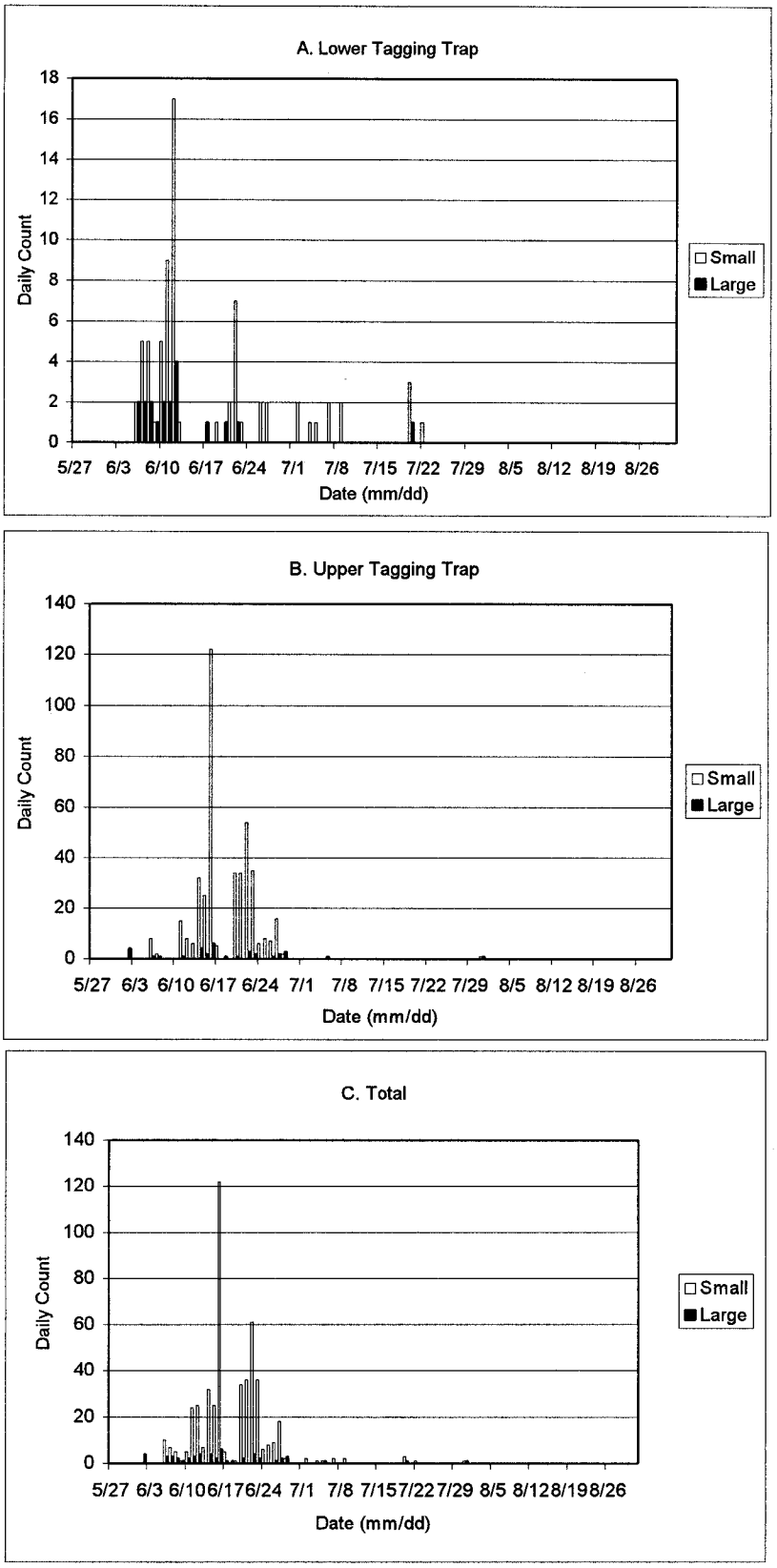


Figure 6. Daily catches of small and large salmon at two tagging traps operated in the estuary of the Humber River, 1999.

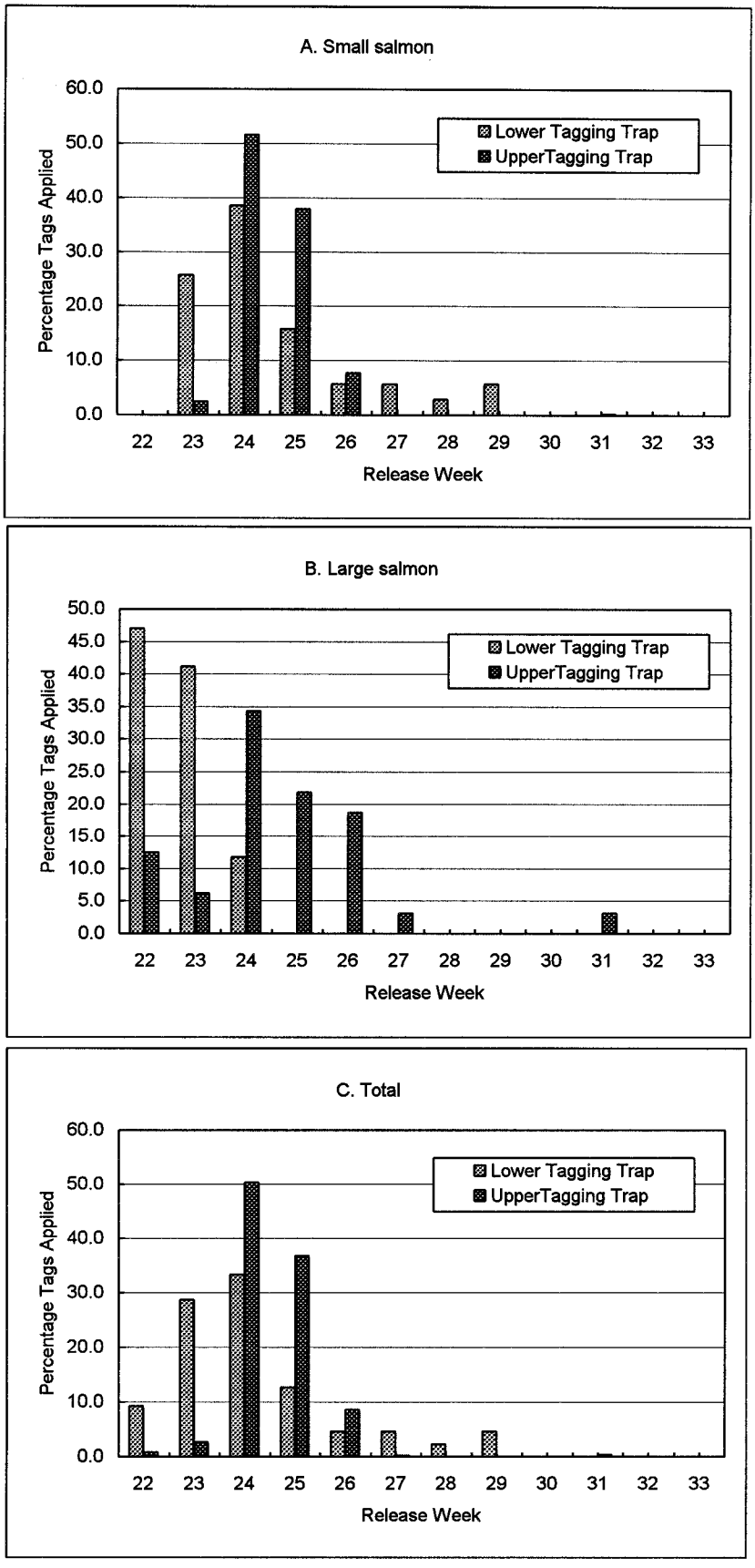
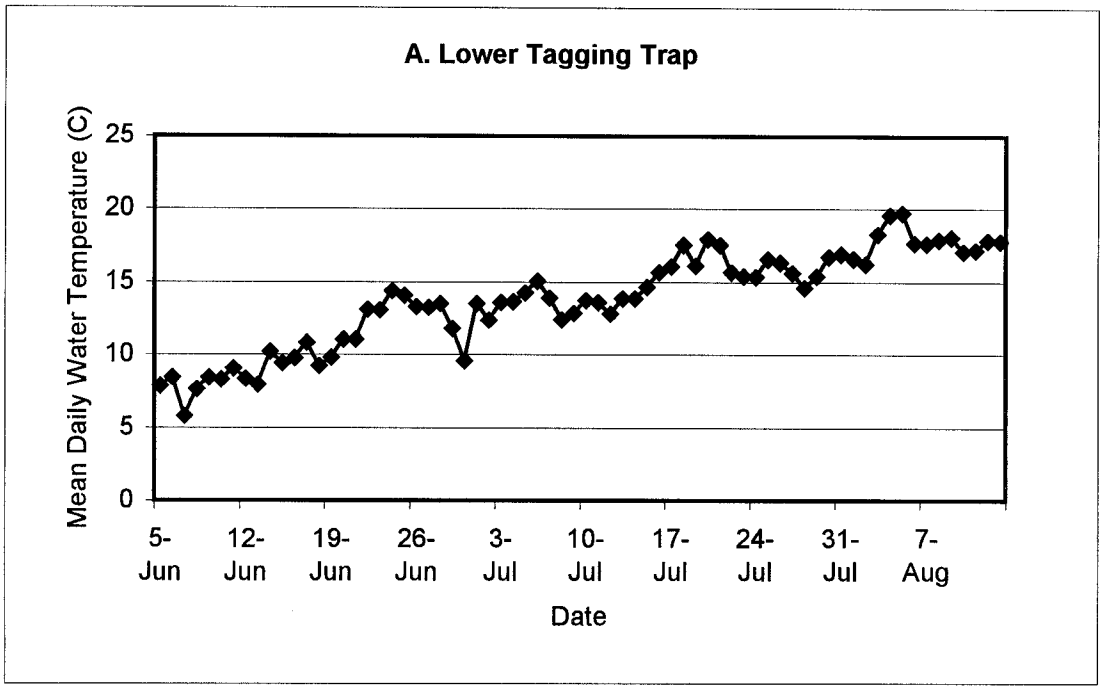


Figure 7. Weekly summary of tags applied to small and large salmon on the Humber River , 1999.



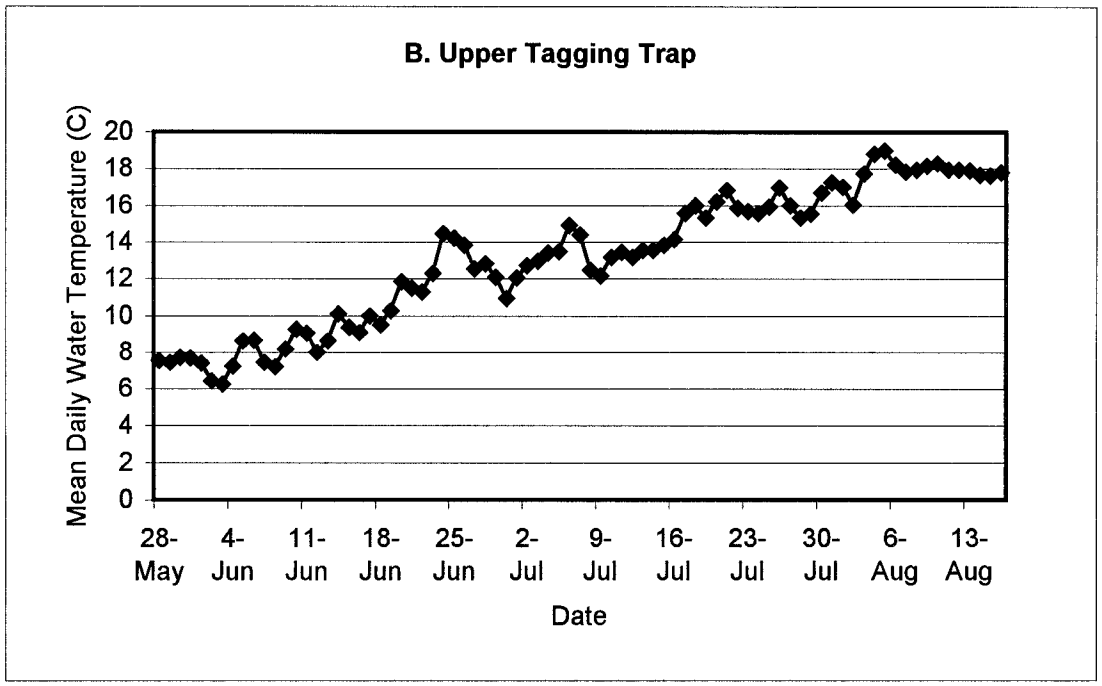


Figure 8. Mean Daily water temperature recorded at the tagging traps operated in the estuary of the Humber River, 1999.

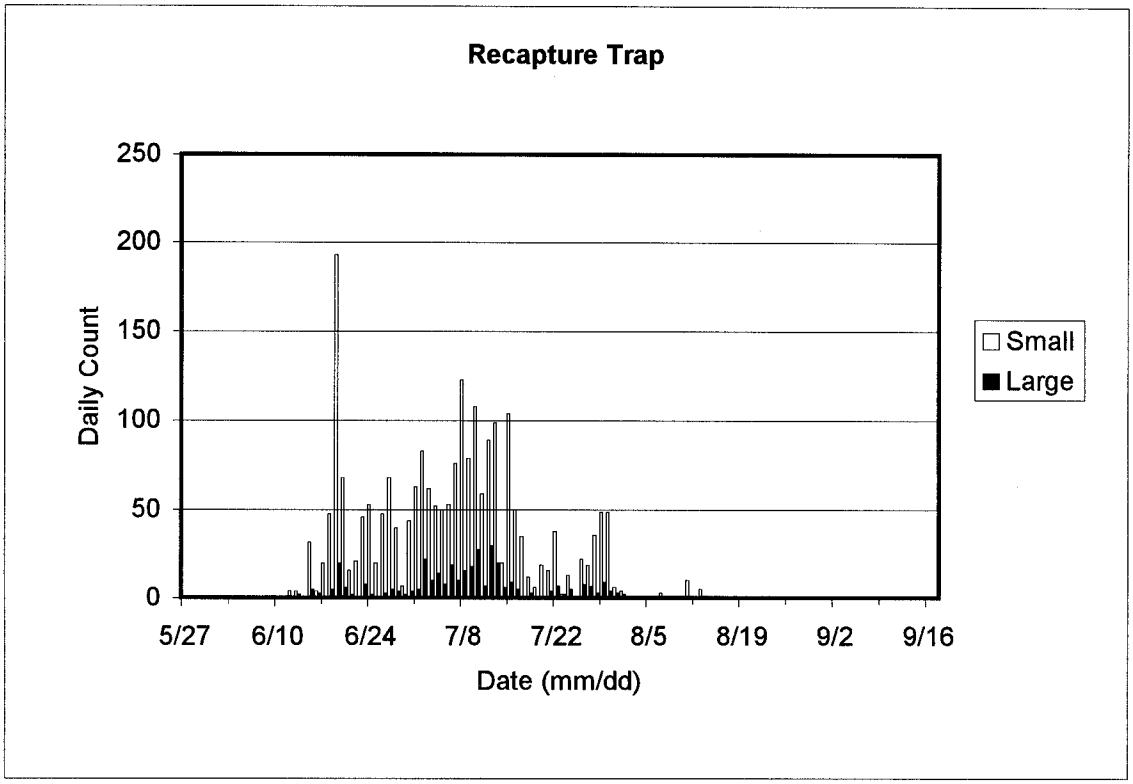


Figure 9. Daily catches of small and large salmon at the recapture trap operated on the Humber River, 1999.

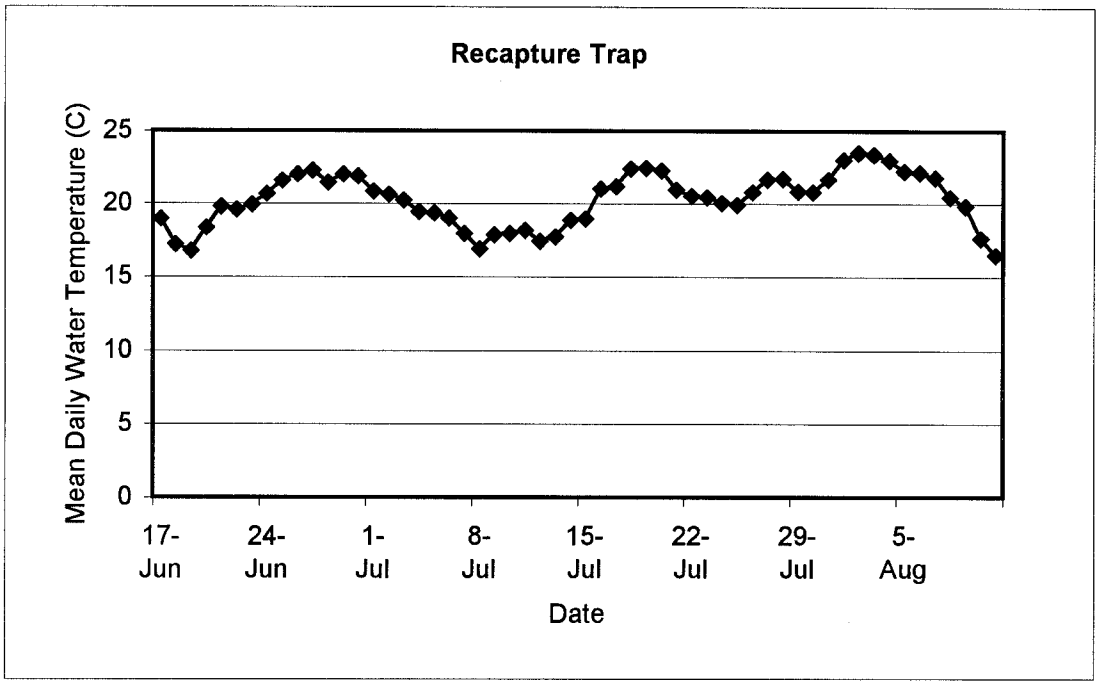


Figure 10. Mean daily water temperature recorded at the recapture trap operated on the Humber River, 1999.

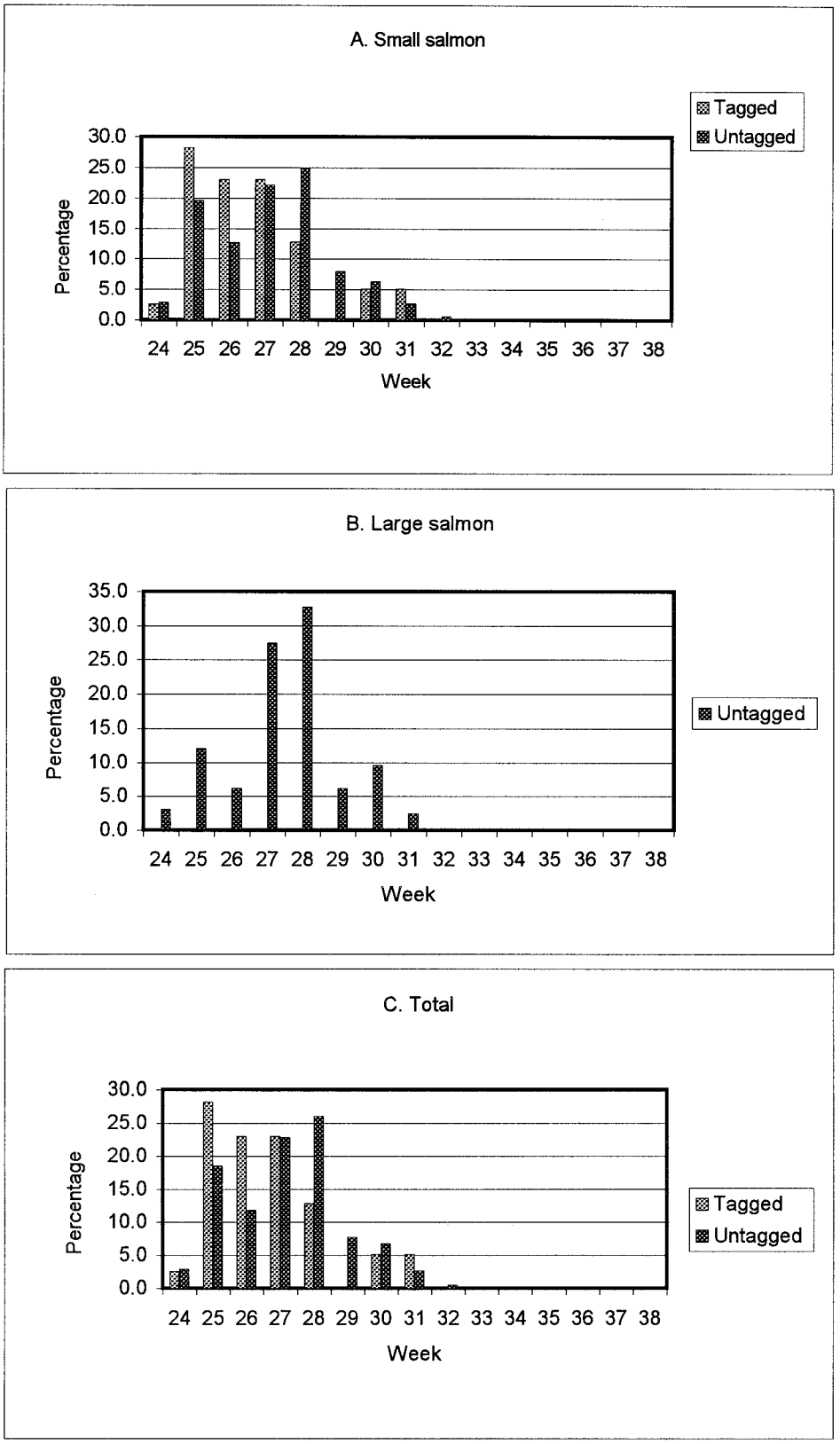


Figure 11. Weekly catches of tagged and untagged small and large salmon at the recapture trap operated on the Humber River, 1999.

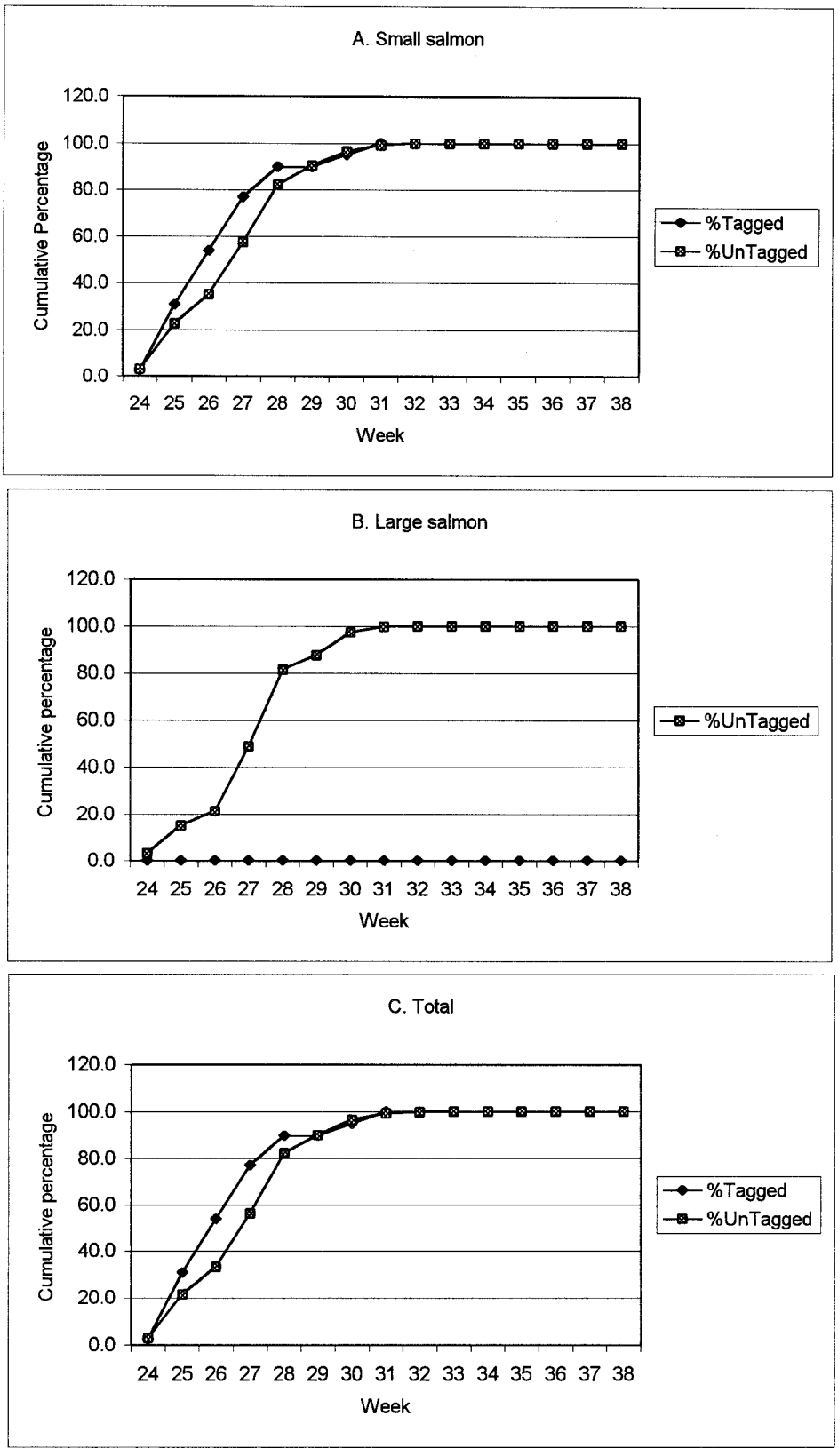


Figure 12. Cumulative weekly percentage of tagged and untagged catches of small and large salmon at the recapture trap operated on the Humber River, 1999.

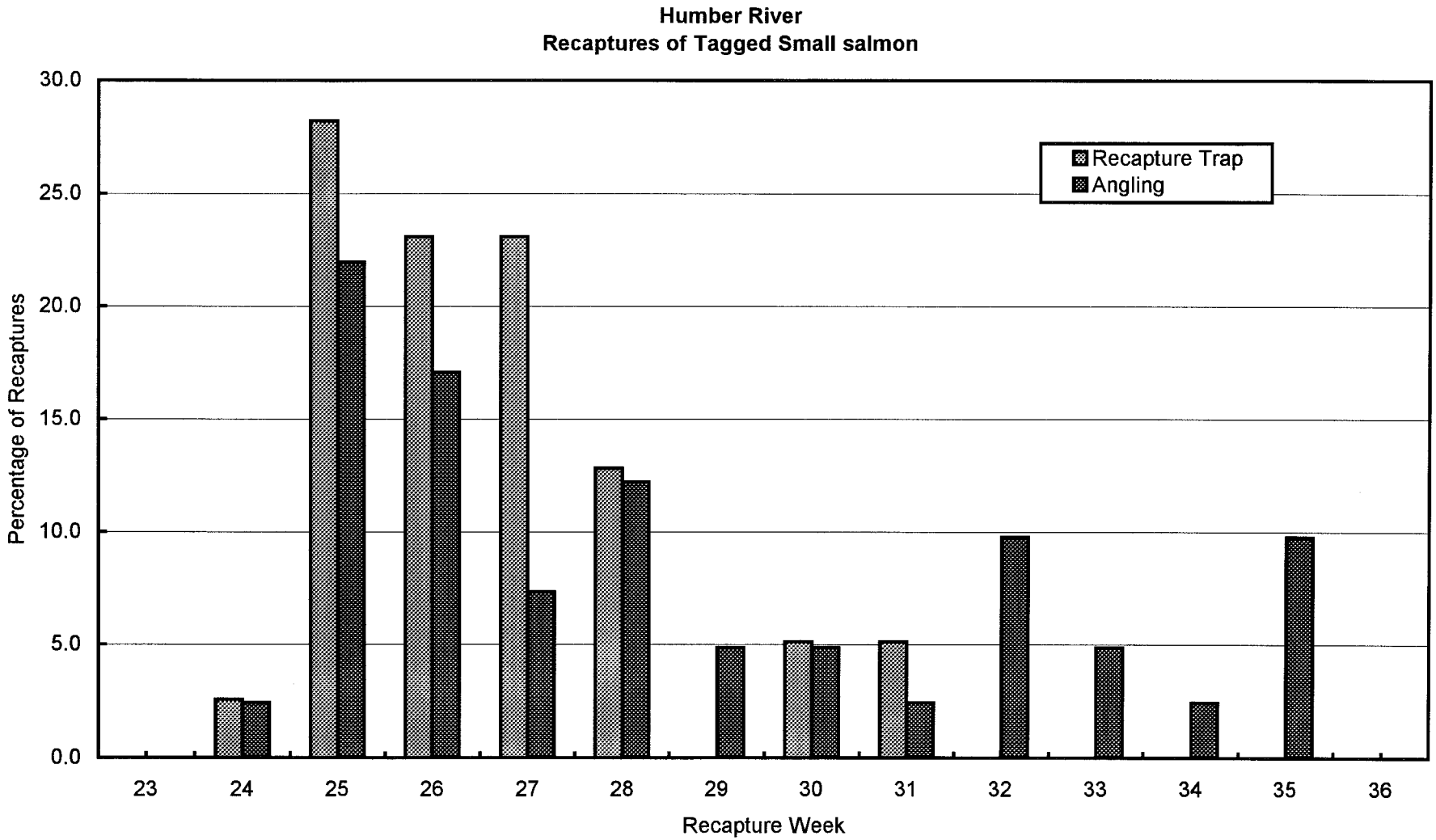


Figure 13. Weekly distribution of recaptures of tagged small salmon in the recapture trap and by angling on the Humber River, 1999.

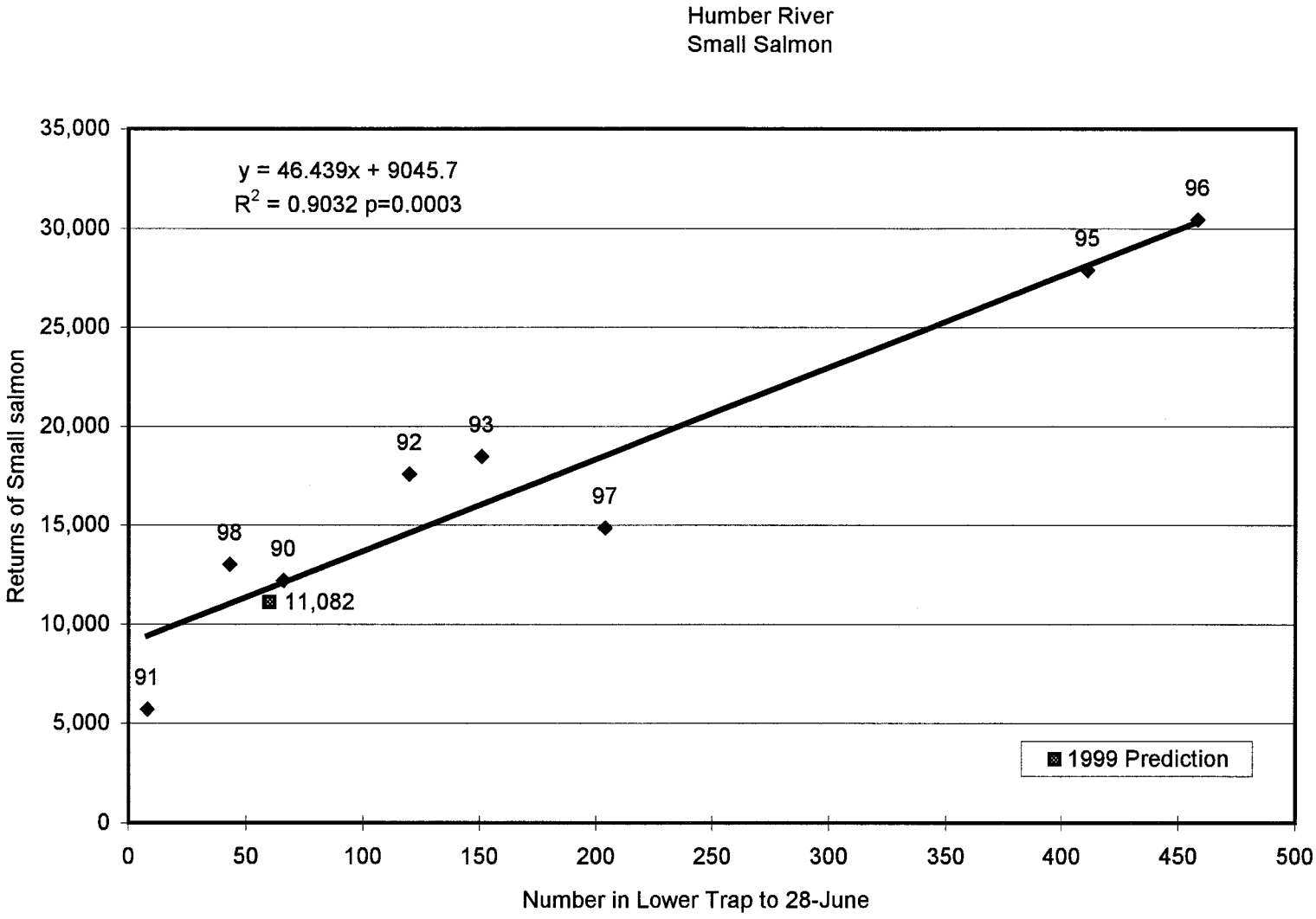


Figure 14. Relationship between the total returns of small salmon and the cumulative catch to 28 June in the lower tagging trap operated in the estuary of the Humber River, 1992-98. The 1994 data point is omitted.

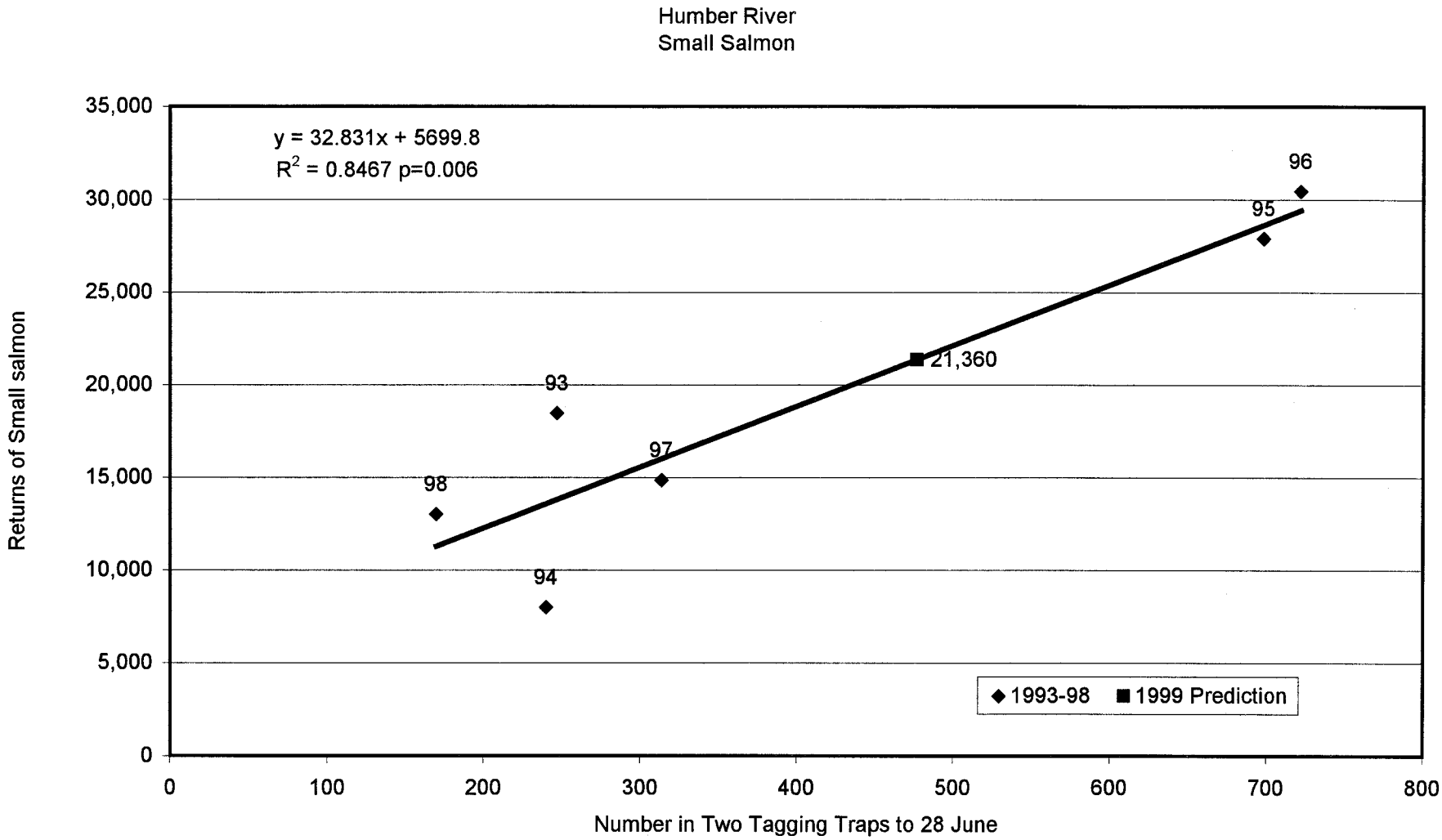


Figure 15. Relationship between the returns of small salmon and the cumulative catch to 28 June in the lower and upper tagging traps combined the Humber River, 1992-98.

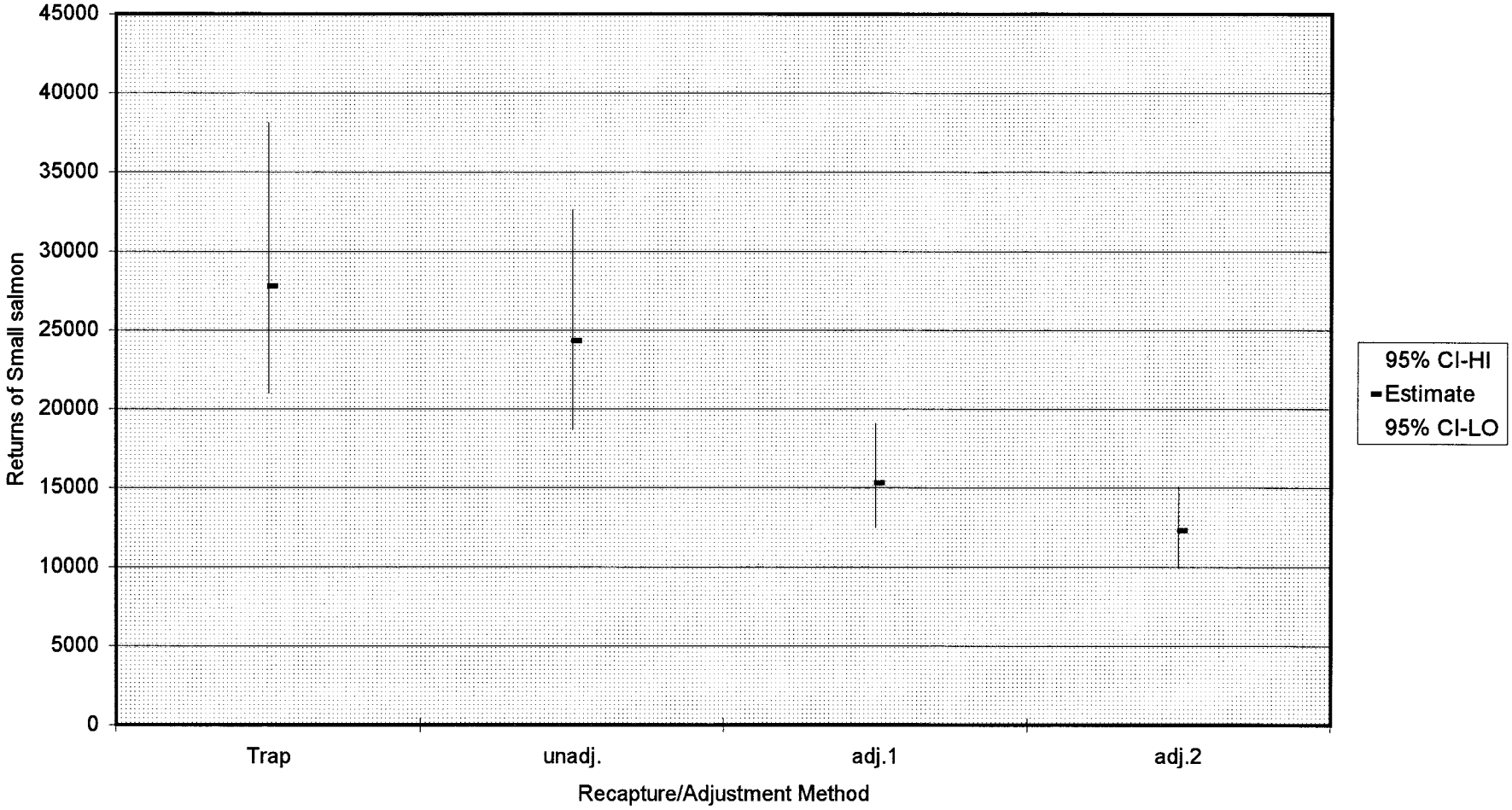
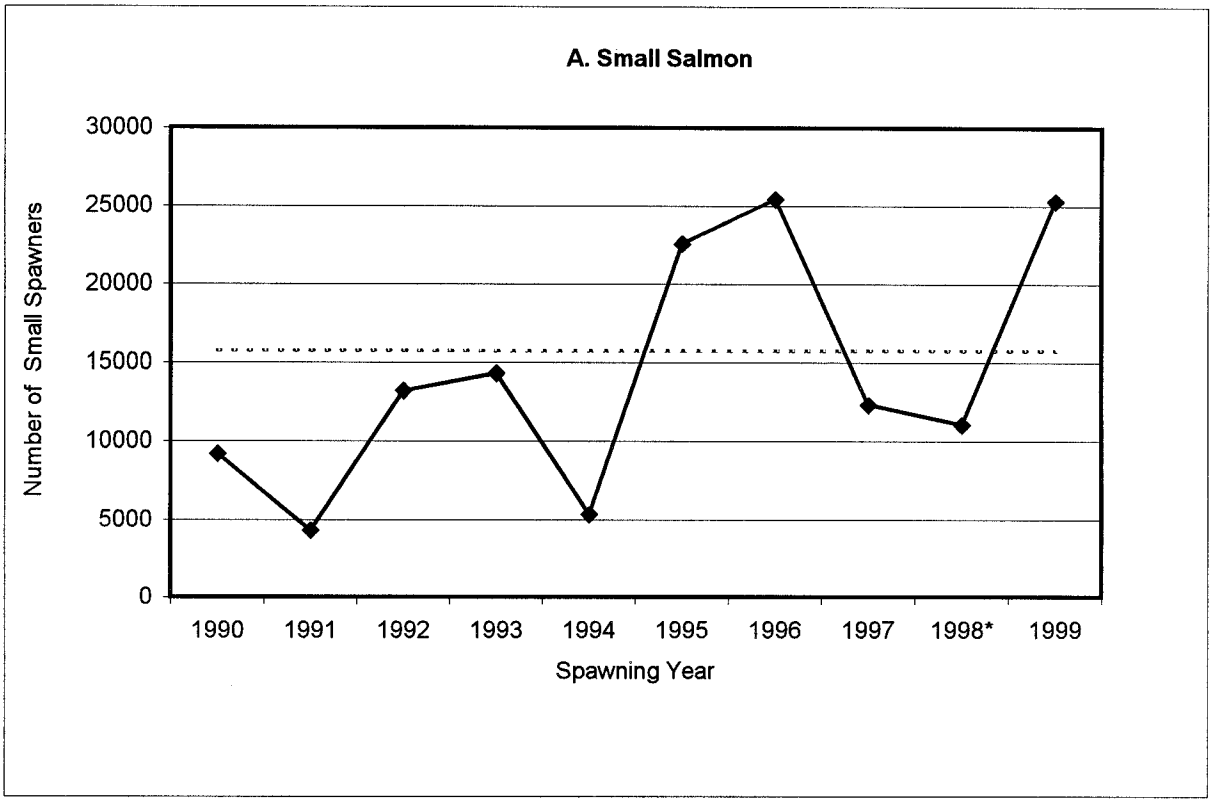


Figure 16. Comparison of returns estimates and 95% confidence intervals for Humber River, 1999.



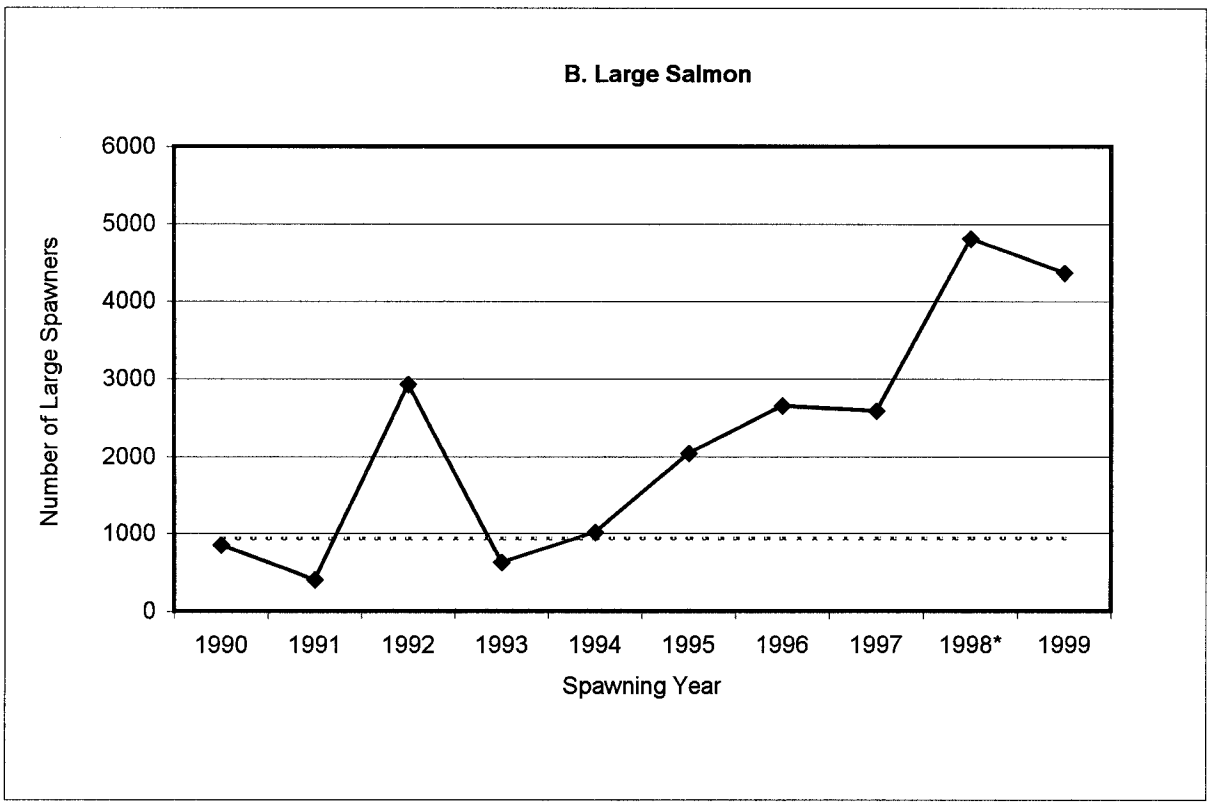


Figure 17. Small and large salmon spawners on the Humber River, 1990-99. Horizontal dashed lines represent conservation requirements in terms of spawners. * Data for 1998 has been updated based on revised angling statistics.

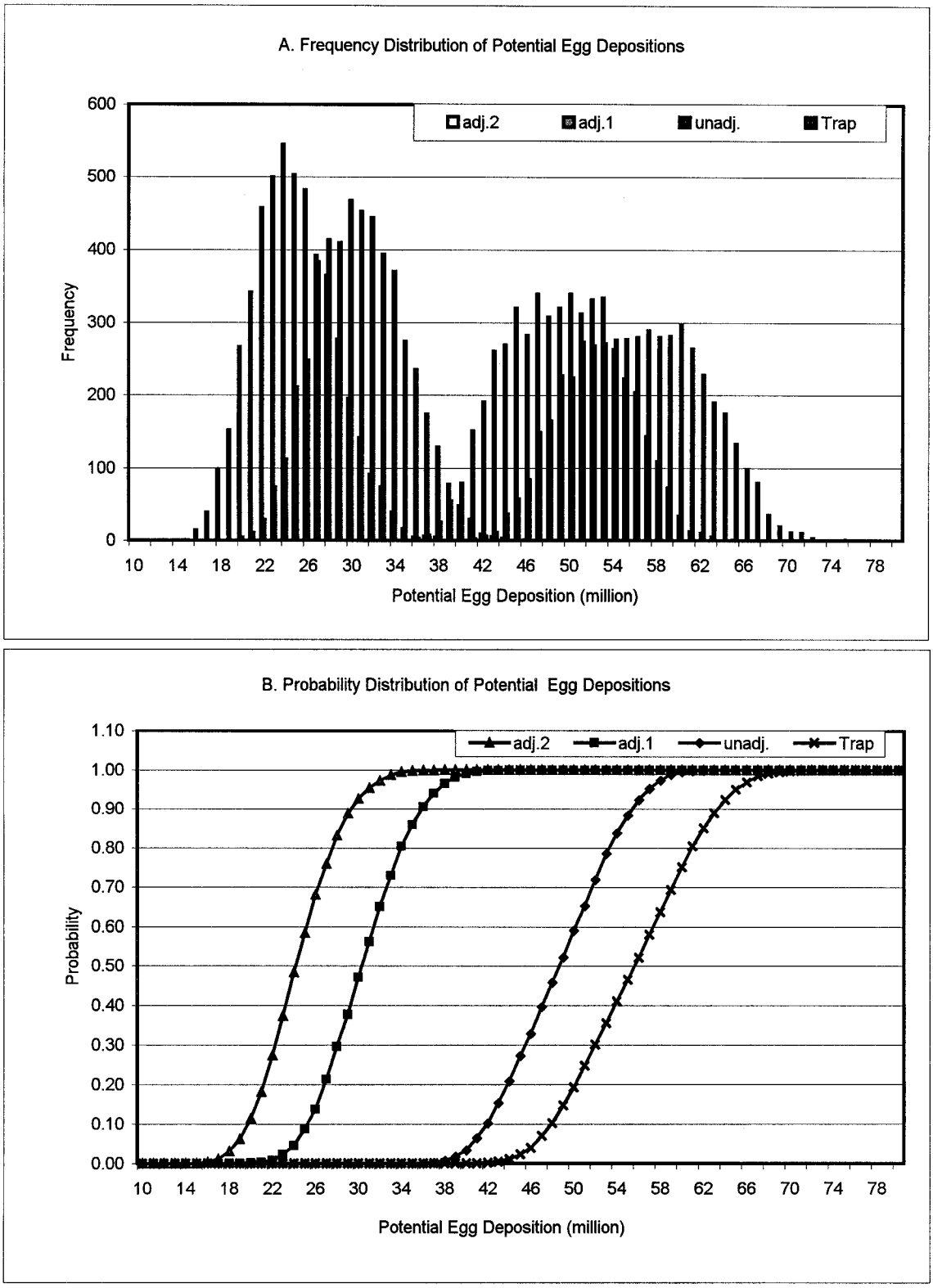


Figure 18. Frequency distribution and corresponding probability distribution of potential egg depositions on Humber River in 1999. Calculations were based on returns estimates from the recapture trap and the three angling adjustment methods.

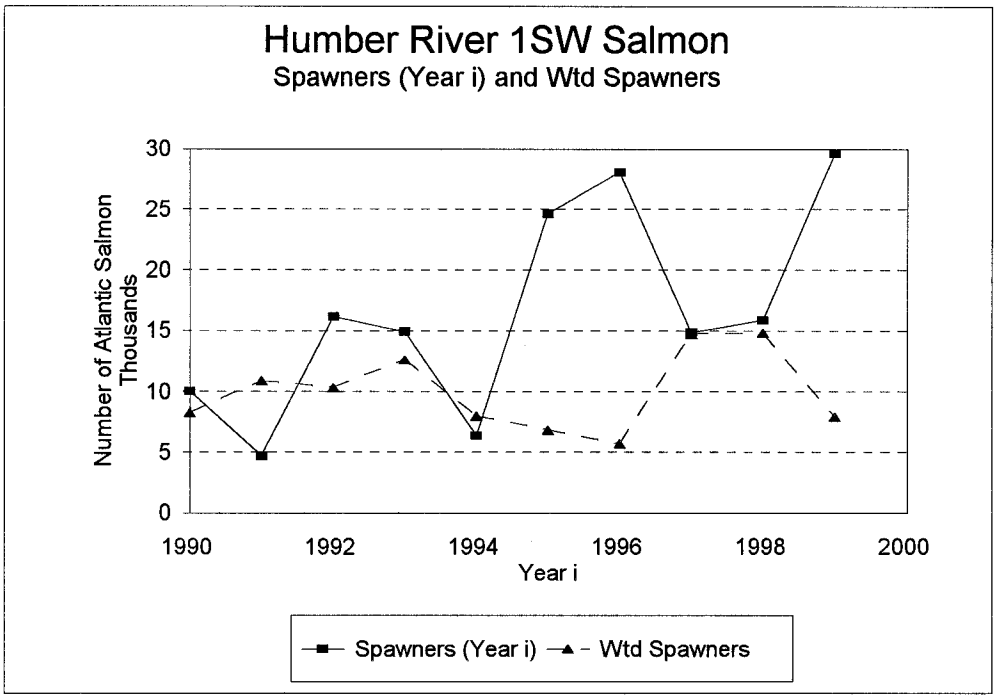


Figure 19. Relationship between total spawners in Year i and spawner recruits adjusted for yearclass (wtd spawners).

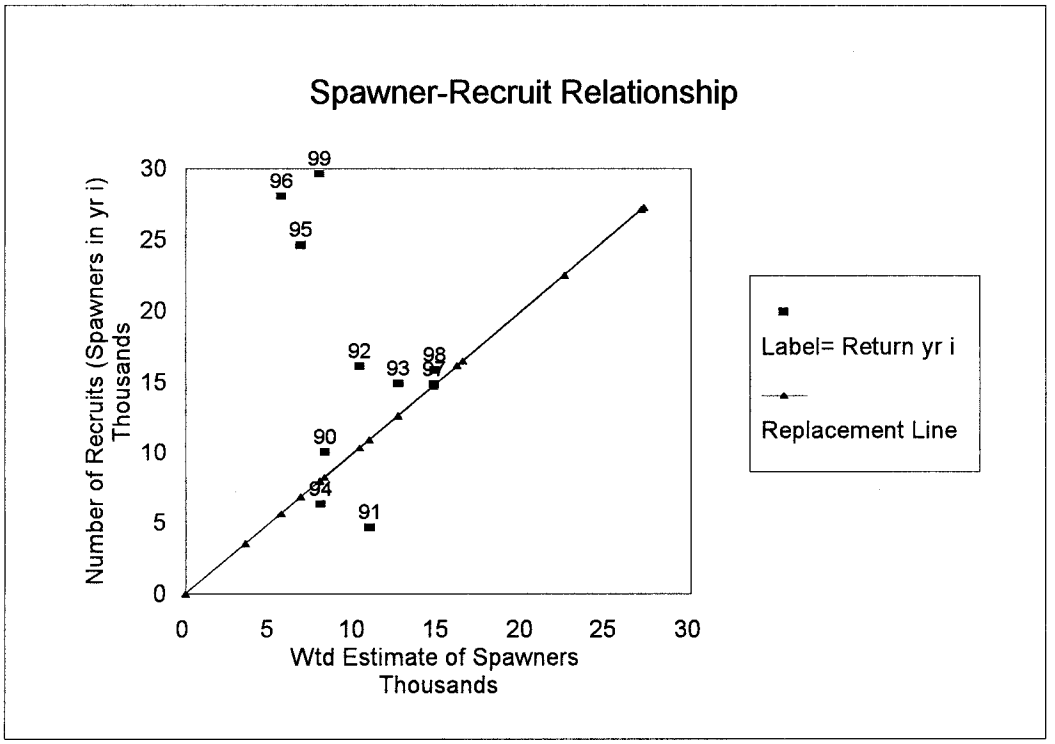


Figure 20. Relationship between 1SW salmon spawners and recruits on the Humber River.

Appendix 1. Recreational salmon fishery catches and effort on the Humber River, 1974-1999.

River: Humber River Code: 4402430

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	8976	2742	.	2742	107	.	107	2849	.	2849	0.32
1975	9611	6147	.	6147	114	.	114	6261	.	6261	0.65
1976	10489	5102	.	5102	61	.	61	5163	.	5163	0.49
1977	6127	2158	.	2158	45	.	45	2203	.	2203	0.36
1978	7633	2722	.	2722	187	.	187	2909	.	2909	0.38
1979	7961	3343	.	3343	27	.	27	3370	.	3370	0.42
1980	8292	3512	.	3512	303	.	303	3815	.	3815	0.46
1981	8701	4132	.	4132	153	.	153	4285	.	4285	0.49
1982	8737	4287	.	4287	95	.	95	4382	.	4382	0.50
1983	7746	3110	.	3110	47	.	47	3157	.	3157	0.41
1984	7189	2872	.	2872	40	.	40	2912	.	2912	0.41
1985	7211	2430	.	2430	*	11	11	2430	11	2441	0.34
1986	8635	3456	.	3456	*	232	232	3456	232	3688	0.43
1987	7250	3074	.	3074	*	113	113	3074	113	3187	0.44
1988	8521	4042	.	4042	*	144	144	4042	144	4186	0.49
1989	6279	1217	.	1217	*	10	10	1217	10	1227	0.20
1990	6918	3021	.	3021	*	75	75	3021	75	3096	0.45
1991	5770	1431	.	1431	*	11	11	1431	11	1442	0.25
1992	6072	2234	194	2428	*	177	177	2234	371	2605	0.43
1993	7023	2206	601	2807	*	125	125	2206	726	2932	0.42
1994	5687	1548	463	2011	*	166	166	1548	629	2177	0.38
1995	6855	1825	705	2530	*	233	233	1825	938	2763	0.40
1996	8978	2448	1350	3798	*	237	237	2448	1587	4035	0.45
1997**		2429	2788	5217	*	505	505	2429	3293	5722	
1998**		1765	2270	4035	*	618	618	1765	2888	4653	
1999**		2223	899	3122	*	689	689	2223	1588	3811	
84-89 $\bar{X}$	7514.2	2848.5	.	2848.5	.	102.0	91.7	2855.2	102.0	2940.2	0.39
95% CL	946.2	1015.7	.	1015.7	.	117.0	92.4	1016.0	117.0	1086.4	0.10
N	6	6	0	6	0	5	6	6	5	6	6
86-91 $\bar{X}$	7228.8	2706.8	.	2706.8	.	97.5	97.5	2706.8	97.5	2804.3	0.39
95% CL	1221.7	1189.8	.	1189.8	.	89.2	89.2	1189.8	89.2	1265.2	0.12
N	6	6	0	6	0	6	6	6	6	6	6
92-96 $\bar{X}$	6923.0	2052.2	662.6	2714.8	.	187.6	187.6	2052.2	850.2	2902.4	0.42
95% CL	1581.3	447.3	533.1	831.3	.	58.9	58.9	447.3	570.5	859.6	0.03
N	5	5	5	5	0	5	5	5	5	5	5

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1985-1996 AND ON RETAINED FISH ONLY PRIOR TO 1985.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.

**DATA OBTAINED FROM THE LICENSE STUB RETURN; 1999 DATA ARE PRELIMINARY